POWER

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Wanted, A Moses!

WHO shall lead us out of the wilderness of conflicting interest, extortionate demand and organized coercion into which we have drifted in the case of our fuel supply?

Commissions are investigating, governors are conferring, officials are puttering around with halfway measures and worn-out ineffectual palliatives

There is a crying need for a strong man who, untrammeled by over-regard for the status quo, dares to wipe the slate clean, start *de novo* and unify aroused public sentiment for a plan to put things right.

In the first place we have got to come to the realization that one may no longer do what he pleases with what is his own, if what he pleases is contrary to the general good.

No man or no set of men can be allowed to buy up all the anthracite coal in the country and tell us to burn bituminous or freeze, any more than any man or set of men can be allowed to buy up all the wheat in the country and tell us to eat corn bread or starve.

This may sound like an infraction of property rights, but the rights of man are superior to the rights of property, and the railroads and other public utilities have submitted to control with a tardy recognition of the justice of this contention.

No man or set of men have any right to interfere with the orderly progress of coal from the mine to the customer; to traffic in the limited supply, to sell it back and forth to each other and load up the price with unconscionable profits. The United States Coal Commission finds that some wholesalers take as much in profit for simply selling a ton of coal as the miner gets for mining it.

The holding up of the public by this refined method is just as reprehensible and should be made just as punishable as highway robbery.

In the absence of slavery no man can be compelled to labor against his will. But the deliberate conniving of a number of men to cease work simultaneously for the purpose of enforcing their demands, to the inconvenience, cost, discomfiture and danger of the public is plain conspiracy and should be so declared in law as well as in fact.

Recognizing that the mining and distribution of coal is "charged with public interest," that it is a public utility, there should be created a body to regulate the operation. This body should represent the public and hold a brief for the public all the time. It should be vested with power to control accounts and profits of operators and dealers and thus, indirectly, the wages of the miners.

And these three parties in interest—the producers and dealers, the miners and workers, and the public as represented by its commission—should be obliged to play the game in the open, with a full knowledge on the part of everybody what it is costing the operator to operate, the miner to live and mine, the handler to handle and the retailer to deliver, and how much each of them is getting out of it.

If the actual cost of putting a ton of coal on the track at the mine, the profit made upon it, the wages paid to the miner per year (not per hour or per day), the cost and kind of his living, what it costs the railroads to haul the coal and what they get out of it, what margins are imposed by middlemen and retailers and how many of them are essential to the distributing system could be flashed upon the screen and become a part of the consciousness of the man upon the street, the coal problem would fade away before an enlightened public conviction as the mists of the morning fade before the rising sun.

F. R. Low

Parke, Davis & Co. Remodel Detroit Power Plant

REMODELING an old plant while maintaining service is no easy task. Parke, Davis & Co., did this and in selecting new equipment to meet the growing load, installed bleeder turbines to co-ordinate more closely the power and heating systems. No exhaust escapes to the atmosphere. It is either utilized or condensed, so that high economy is secured.

FOR a great many years Detroit has been the home of Parke, Davis & Co., manufacturers and world-wide distributors of pharmaceutical products and biological preparations. The Detroit laboratory, the largest of their various plants, manufactures for the domestic trade as well as for the export trade to Latin America. Their Canadian, European and Australian customers are served from laboratories at Walkerville, Ont.; London, Eng.; and Sydney, N.S.W. The Detroit plant occupies about 15 acres on the Detroit River front, the various offices and laboratories being scattered over what would be the equivalent of six city blocks of ordinary size. Some 2,500 people are employed here. The manufacturing processes require a wide variety of services in the way of steam for heating and process work, light and power, refrigeration, hot and cold water and compressed air, all of which have been supplied from a central power plant built up step by step with the growing requirements of the company.

As is usual in a case of this kind, the plant consisted of a miscellaneous collection of non-condensing engine-driven units of comparatively small size, later a mixed pressure turbo-generator to insure full utilization of exhaust steam, eight water-tube boilers of vertical and horizontal design equipped with obsolete underfeed stokers, a couple of steam-driven air compressors with an aggregate capacity to deliver 1,850 cu.ft. of air per minute, and 325 tons of refrigeration in four units, motor driven and located in the departments served.

Years of service brought the old plant to a point where much of the equipment was becoming obsolete, some of it worn out, and the capacities as a whole inadequate for the demands made by increasing pro-

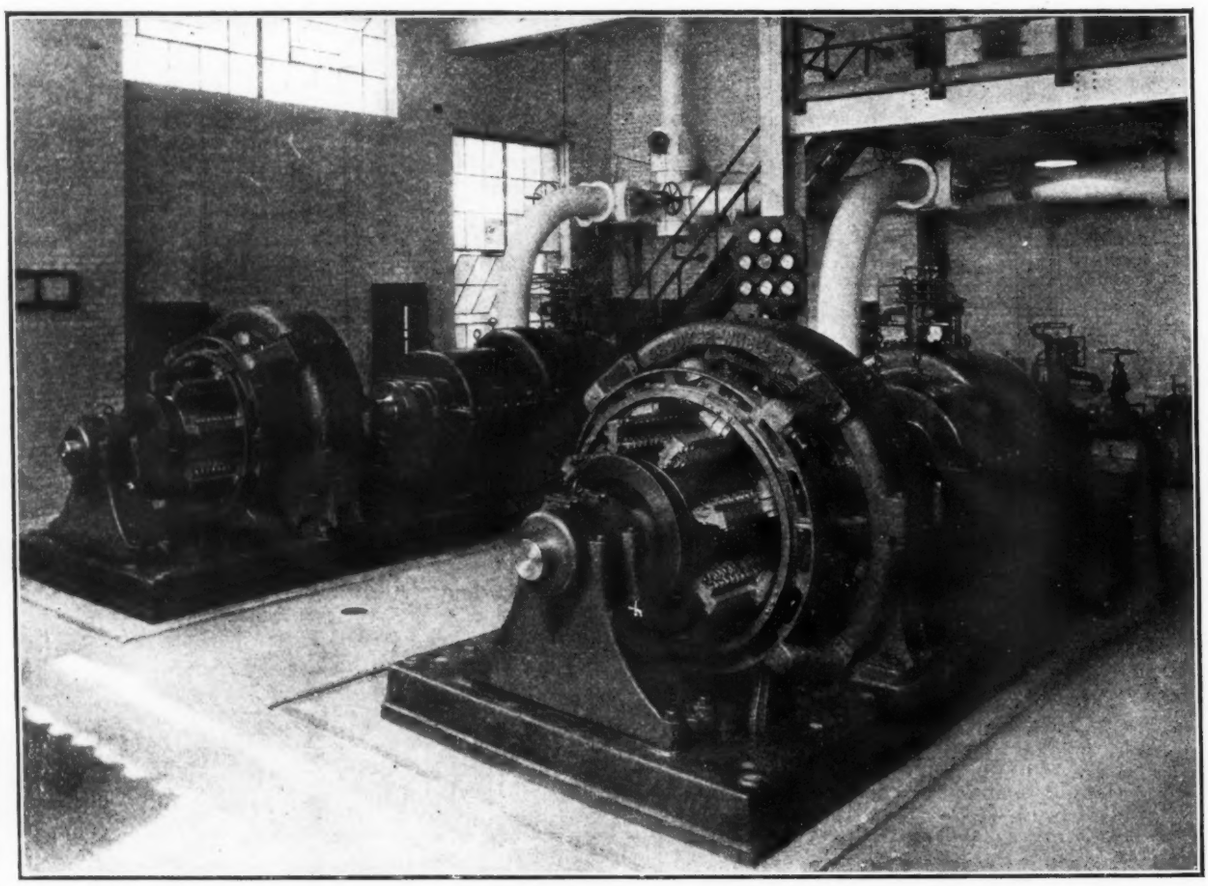


FIG. 1—NEW BLEEDER TURBINES GEARED TO DIRECT-CURRENT GENERATORS

duction. More capacity was needed in the boiler room and a larger electrical output. A careful survey was made to determine the various loads and to investigate the possibilities of co-ordinating heating and power steam.

Direct Drive Employed to an Unusual Extent

This survey showed, in the power and light investigation, that very little lineshafting had been employed. For a plant of its size the company had gone farther than most concerns with direct drive. For the machinery installed throughout the works, there is a total of 603 electric motors of various sizes, giving a connected load of 2,108 hp., but only 126 of these motors are rated at over 5 hp., while 356 are of 1-hp. capacity or less. The total connected load is 1,756 hp. in 110-volt direct-current motors and 351 hp. in 440-volt alternating-current machines, the use of the alternating current being confined to the coal-handling equipment in the boiler room and to a few comparatively large installations in one or two of the manufacturing departments. For electric lighting there is a connected load of 378 kw. in direct current only. As shown in Fig. 3, the daily electrical demand, including both alternating and direct current, averages around 675 kw. during business hours with peaks running up to over 800 kw. In addition a little purchased service is used exclusively for night work in one department.

For heating offices and laboratories the equivalent of 54,000 sq.ft. of direct radiation has been provided. It has been estimated that this load will require 5,000 sq.ft. of boiler surface or in the colder weather about 15,000 lb. of steam per hour. Exhaust steam at about 5 lb. pressure is used for heating.

Process steam for manufacturing purposes is piped over practically the entire plant. This demand calls for 7,500 sq.ft. of boiler surface, or an average of about 22,500 lb. of steam per hour. From the boiler room the steam is distributed at 40 lb. pressure and where necessary is further reduced at the point of service.

Two Water Supply Systems

For water supply there are two distinct and separate systems; that is, water direct from the city mains is used for many purposes, but in addition large quantities of water are pumped from the Detroit River. This service water is used for purely mechanical purposes, principally for the condensing. The plant contains two 150-ton and one 10-ton ammonia refrigerating units and one 15-ton CO_2 machine, in addition to a large number of stills of all kinds and sizes, all of which are provided with surface condensers. Something like 1,000 gal. per min. of water is pumped for this purpose.

The laboratories are piped throughout for the distribution of air compressed to 50-lb. pressure, but reduced in pressure in the departments to suit conditions. The air is used principally for handling liquids and for a number of other purposes. During business hours the demand averages about 1,300 cu.ft. per min.

Something like 65,000 gal. of hot water is used daily. Taken from the city mains, it is heated to about 190 deg. F. with exhaust steam and distributed to all departments of the plant.

From the survey it was evident that more steam is required for heating and process work than for power. The purchase of current had been considered, but the recovery of power as a byproduct of the heating steam offered so great an advantage that the decision to continue electric generation was inevitable. It was decided to install two new generating units, with space for a third, and to retain that portion of the equipment still in good condition, such as the mixed-pressure turbine, an engine unit for night service and a motor-generator set for transposition from direct to alternating current or vice-versa. In the boiler room the same policy was pursued. Two new boilers replaced two of the older ones, and the remaining six boilers, still in fair condition, were retained for the time being, although the plan is eventually to replace all old equipment.

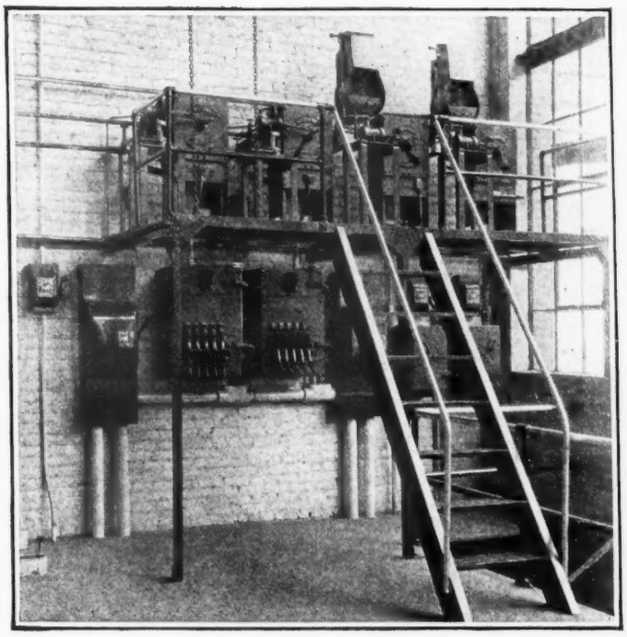


FIG. 2—AUTOMATIC CONTROL EQUIPMENT FOR STOKER AND FAN MOTORS

Under the new equipment in both boiler and turbine rooms a basement was required, so that it was necessary to elevate the floors 7 ft. in one case and 10 ft. in the other, the old equipment remaining at the original level, as service had to be maintained while the new work was in process.

Economy of Operation Considered

Although reliability was the first consideration in remodeling the plant, economy was not overlooked. A complication was the need for steam at two different pressures. Attempts had been made to utilize steam at 5 lb. pressure for the process work, but the making in succession of different articles in apparatus often requiring different temperatures, necessitated steam at 40-lb. pressure for this purpose, this being drawn from the boilers. Operating the entire exhaust-steam system at such a pressure would have been impracticable, and the same argument would apply to bleeding steam at this pressure from the main turbines, considering an initial pressure of only 125 pounds.

Utilization of the exhaust steam at 5-lb. pressure for heating and in certain drying rooms also offered complications, as the demand varied considerably from day to day and even throughout the day. At night the load was comparatively light. With non-condensing operation, steam would be wasted to atmosphere, particularly through the summer months. Bleeder turbines operated condensing offered a solution, and machines of

this type were installed to drive the new generating units.

From venturi charts it had been determined that the total feed water per month to the boilers amounted to approximately 30,000,000 lb., this being equivalent to about 60,000 lb. an hour during business hours and a little less than 30,000 lb. an hour at night. Typical curves made up during the survey to indicate the daily steam demands are shown in Fig. 4. Saturated steam is generated at a pressure of 125 lb., the present boiler equipment being as follows:

Two New Boilers Added

The two new boilers are of the horizontal cross-drum water-tube type containing 6,090 sq.ft. of steam-making surface. They are vertically baffled as indicated in the sectional elevation, Fig. 5, and are placed in individual settings over 6-retort underfeed stokers equipped with steam-operated ash dumps. The furnace width is 12 ft. and the height from the floor to the bottom of the front tube header, 12 ft. Each stoker is 10 ft. 10 in. wide and 9 ft. 1 in. deep, with a projected grate area of 98.4 sq.ft. bearing a ratio to the steam-making surface of 1 to 62. The stokers are driven by 5-hp. direct-current motors, with a speed range from 400 to 1,600 r.p.m., provided with automatic control and hand starters. Two forced-draft fans, each with a capacity of 35,000 cu.ft. per min., are capable of operating the present two boilers and a future boiler of the same size at maximum capacity. It is the intention to operate the boilers at about 175 per cent of rating. The fan speed is controlled by pressure regulators connected to the boiler header, while the static pressure in the forced-draft duct automatically governs the speed of the stoker motors, the two regulators in each case controlling the positions of the motor rheostats.

Of the older boilers retained there are three of the vertical water-tube type set in one battery which are

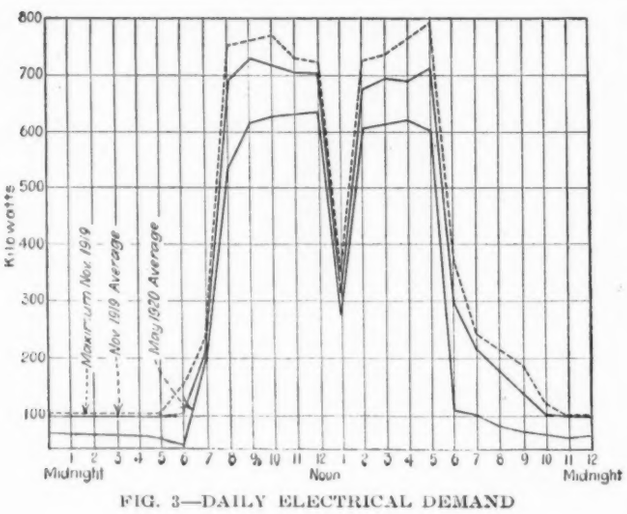


FIG. 3—DAILY ELECTRICAL DEMAND

to be used as incinerators for the disposal of refuse, of which there comes from the laboratories each day a considerable volume that is difficult to burn; namely, about 15 tons of wet spent drug (leaves, barks and roots, ground fine or coarse) from which the medicinally active portions have been removed. This material contains all the water it can take up, and as it will ferment and sour soon after it cools, it must be disposed of the same day that it is produced. For this purpose the Dutch ovens serving the vertical water-tube boilers lend themselves readily.

To receive this material from the street, a hopper of 400 to 500 lb. capacity has been provided. From the hopper the material is removed by a bucket elevator which delivers to a drag conveyor running across the tops of the Dutch ovens. Along the side walls of each firebox, holes 10 in. square have been cut through the

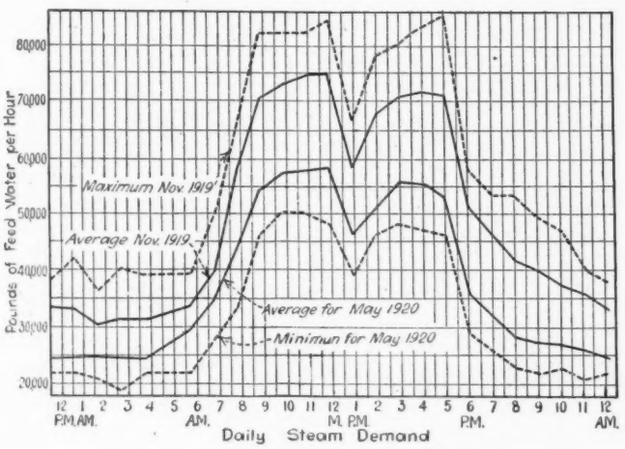

80000
70000
60000
50000
40000
30000
20000
Pounds of Feed Water per Hour
Maximum Nov. 1919
Average Nov. 1919
Average for May 1920
Minimum for May 1920
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
P.M. A.M. A.M. M. P.M. P.M. A.M.
Daily Steam Demand

FIG. 4—DAILY STEAM DEMAND

arch and a chute connects each of these openings with the drag conveyor above. In each chute is a counterpoised damper. When the conveyor has deposited enough material in the chute to overbalance the counterweight, the damper opens and allows the material to slide into the firebox; then closes automatically behind it.

In the firebox the underfeed stokers tend to heap up the coal over the retorts, so that this material falling in along the side walls does not mix much with the fire. It is allowed to lie there piled up, until it dries out and burns away spontaneously at the edge of the pile. Formerly, when it was burned by being mixed with the coal, about a pound of coal was required to burn up a pound of refuse. Burned as described previously, it has a fuel value of about one-fifth that of coal and, of more importance, it is possible to dispose of it as fast as it collects. During the night the boilers are fired with rubbish, such as wood boxes, barrels, paper and hay in such condition that it cannot be reused. Enough coal is added to maintain operation at normal rating, and the boilers are depended upon to produce steam only to this extent.

Three Horizontal Boilers

In addition to the vertical boilers there are three horizontal longitudinal-drum, water-tube boilers each containing 2,500 sq.ft. of steam-making surface. As in the case of the vertical boilers they are arranged three in a battery and equipped with the same type of underfeed stokers. They have seen a number of years of service and, although in good condition, are held in reserve. Table I gives a summary of the steaming capacities that may be expected from the present equipment.

From the new boilers, uptakes rise vertically to a breeching on the roof, which leads to a new radial-brick stack 9 ft. 6 in. in diameter at the top and rising 200 ft. above the grates. It is large enough to care for the future third unit previously mentioned. The older

boilers, connected to a common breeching inside the boiler room, are served by the original brick stack, which is of octagonal design, 7 ft. 6 in. across at the top and 175 ft. high.

Annually, about 18,000 tons of West Virginia run-of-mine coal is burned in the plant. The quality is maintained in the vicinity of 14,000 B.t.u. per lb., 6 per cent ash and less than 1 per cent sulphur. In extreme winter weather the daily consumption runs up to 75 tons. Shipments are received by rail and a storage supply large enough to carry over any tie-ups in traffic is maintained.

The boiler room is located along the Belt Line Railroad. Hopper-bottomed cars are dumped from the railroad siding into a track hopper, from which a steel apron feeder transfers the coal to a single-roll crusher in the basement of the boiler room. The crusher delivers into an 18x24-in. pivoted-bucket carrier which makes a circuit of the boiler room longitudinally delivering to a 250-ton steel bunker serving the older boilers and to a 350-ton concrete bunker built for the new boilers. The capacity of the coal-handling equipment is 50 tons an hour. A 1-ton traveling weigh larry is interposed between the bunker and the stoker hoppers.

At the end of the steel bunker a pocket has been partitioned off to hold two days' accumulation of ashes. Under the new boiler tile-lined hoppers hold a maximum accumulation of ashes during 36 hours. These hoppers are equipped with gates operated by compressed air, and the ashes are dumped into industrial cars running on tracks to the pivoted bucket carrier, where the transfer is made to the lower run of the conveyor and the ashes delivered to the overhead bunkers. A chute through the wall makes possible delivery to motor trucks in the street or to railway cars. From the older boilers the ashes are raked out through doors in the stoker front and through a hatch down to the basement floor, from where they are shoveled into the lower run of the pivoted-bucket carrier, to be conveyed to the overhead ash bunker.

Where feasible, returns from the steam-using equipment in the laboratories and from the heating system are brought back to the power plant and collected in a hotwell, which also receives the condensate from the main turbines and the clean drips from the high-pressure piping. Over two-thirds of the feed water used in the boilers is collected in this way and the makeup which is drawn from the city mains, is admitted to the hotwell under float control. Two motor-driven pumps, each rated at 300 gal. per min., one in use and the other a reserve unit, transfer the water from the hotwell to the feed-water heaters, which are located on the mezzanine in the turbine room. The two heaters employed have been retained as equipment that is still serviceable. The heaters are connected to the common exhaust main receiving the exhaust steam from all auxiliaries and from the main turbine-generator units. A temperature of 214 deg. F. is maintained.

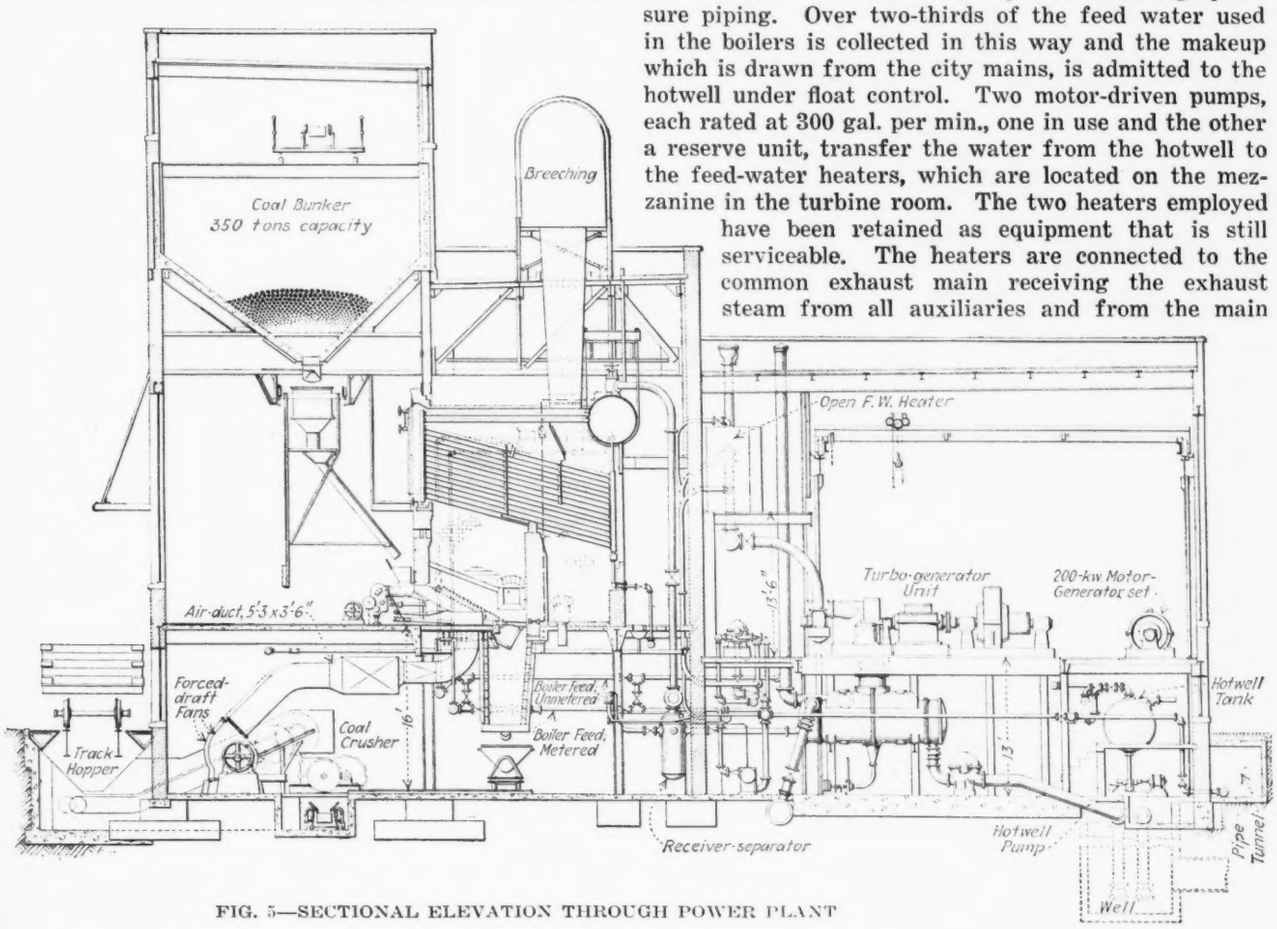


FIG. 5—SECTIONAL ELEVATION THROUGH POWER PLANT

Fig. 5, a sectional elevation through the plant, shows the location of the main steam header. The two sections serving the new and old boilers are joined by a U-expansion bend. Reducing valves at each end connect the header to the 40-lb. process steam system of the laboratories, while steam to the main turbines and to auxiliaries is taken off through separators of ample size connected to the bottom of the header. This unusual location of the receiver separators allows simultaneous drainage of the header and the various supply lines.

The exhaust main, a 14-in. pipe, is hung from the mezzanine gallery and runs the entire length of the turbine room. It receives exhaust steam from the non-condensing equipment in the plant and is connected also to the bleeder turbines through multi-ported back-pressure valves. These valves are set so that sufficient

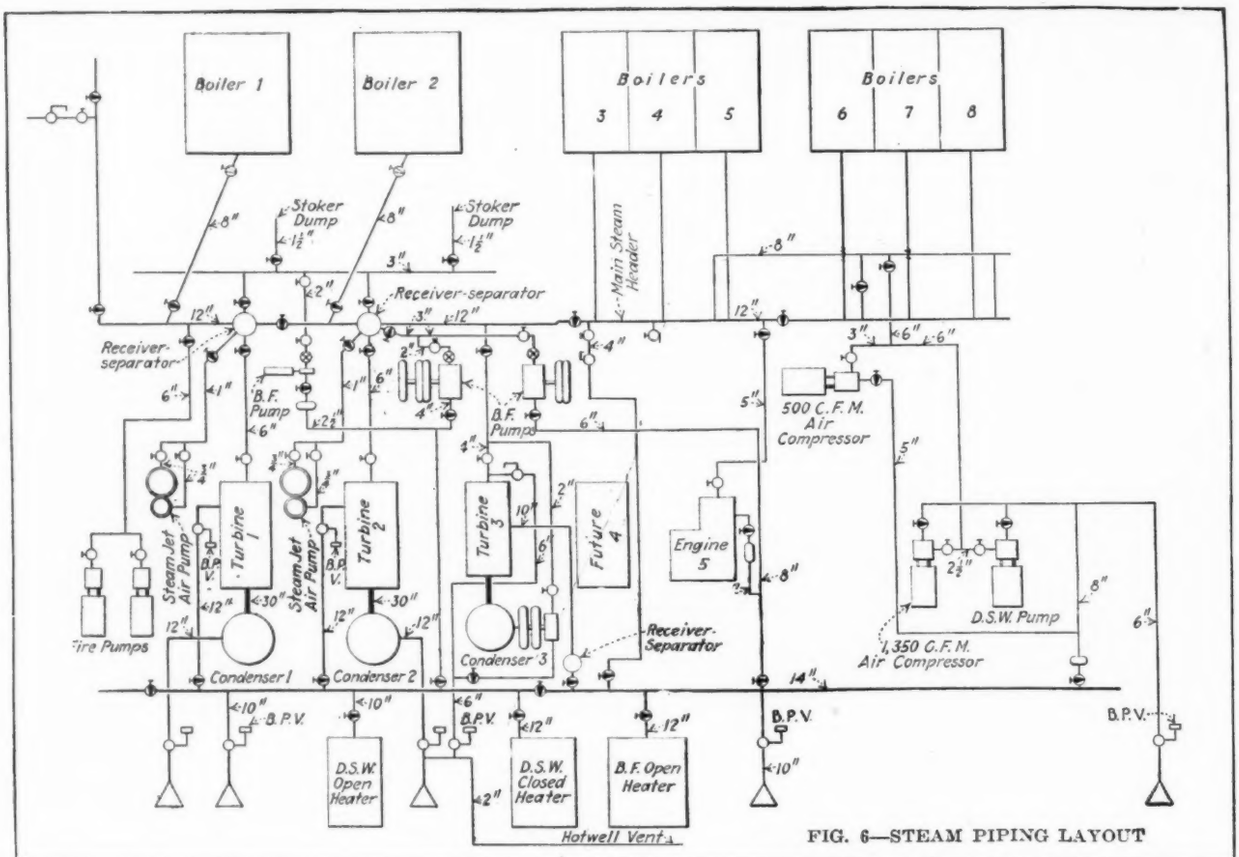


FIG. 6—STEAM PIPING LAYOUT

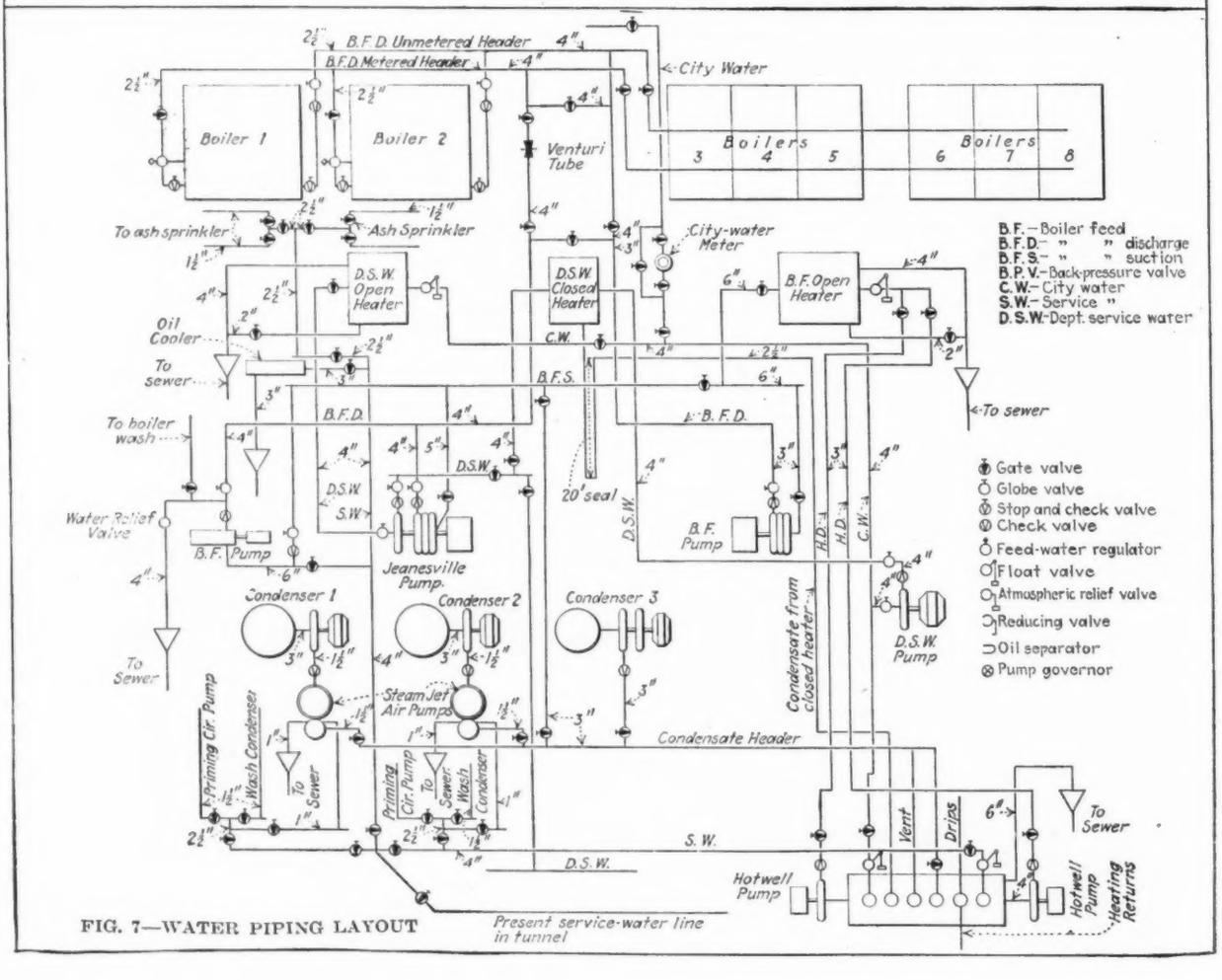


FIG. 7—WATER PIPING LAYOUT

steam is bled from the main turbines to maintain a constant back pressure approximating 5 lb. The main is connected at either end with the heating system and also to the boiler feed and hot-water heaters.

In the turbine room the new generating equipment consists of the two bleeder-type multi-stage turbines

TABLE I—SUMMARY OF BOILER CAPACITY

Units	Surface Each, Sq.Ft.	Rated Capacity Lb. Steam per Hr.	Maximum Capacity Lb. Steam per Hr.
2 Cross-drum	6,090	36,540	90,000
3 Vertical	3,330	30,000	30,000
3 Long drum	2,500	22,500	30,000
Total		89,040	150,000

connected through 5,000 to 600 r.p.m. reduction gears to 500-kw. 125-volt 40-deg., compound-wound, direct-current generators. Each unit is served by a surface condenser containing 2,150 sq.ft. of surface, which reduces to 4.3 sq.ft. per kilowatt of generator rating. The circulating and condensate pumps are of centrifugal

TABLE II—ECONOMY OF AND STEAM EXTRACTION FROM BLEEDER TURBINES

Load	Lb. Steam per Kw.-Hr.	Steam at Throttle, Lb.	Steam Extracted, Lb.	Steam to Condenser, Lb.
1¼	19.9	23,000	14,000	9,000
Full	19.5	23,000	17,500	5,500
¾	20.2	23,000	20,800	2,200
½	21.7	14,200	13,200	1,000

type, motor driven, their respective capacities being 2,600 gal. per min. and 52 gal. per min. The air is removed by steam jets with inter and after condensers, each device having a capacity to remove 10 cu.ft. of free air per min. Table II gives the guarantees relative to steam consumption and steam extraction for this equipment.

Water for house service and condenser cooling is taken from the Detroit River at the dock-face, about 800 ft. distant from the power house. Through a concrete intake pipe the water passes into a new screenhouse containing a motor-driven traveling screen 72 in. wide and 20 ft. 6 in. on centers. From the screenhouse the water flows by gravity through two intake lines of ordinary sewer construction to wells located at different points on the premises. One of these lines is 30 in. in diameter and has been installed for a number of years. A new 36-in. line is being added to provide more capacity. One of the wells is in the basement of the turbine room convenient for suction connections from the condenser circulating pumps. The service-water pumps and the underwriter pumps have their individual

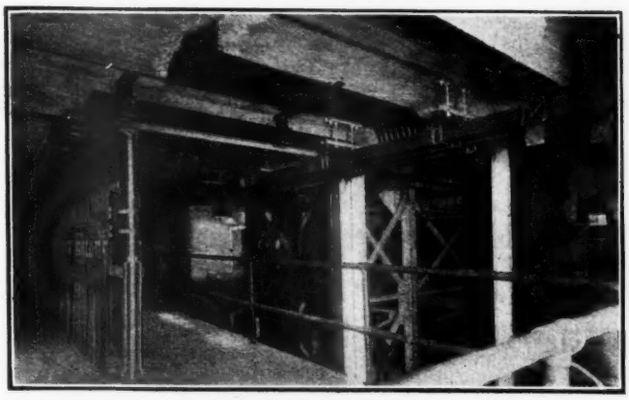


FIG. 8—COPPER WORK IN BASEMENT

wells, and there are other wells from which some of the apparatus used in process work takes water directly. The condenser discharge passes through a storm sewer on its way back to the river.

Alternating-current generating equipment is provided in the mixed-pressure turbine unit previously mentioned. The turbine is connected to a 300-kw. 480-volt alternating-current generator having a speed of

NEW EQUIPMENT IN PARKE DAVIS PLANT

BOILERS

Manufacturer	Babcock & Wilcox Co.
Type	Cross-drum water tube
Number	2
Heating surface, sq.ft.	6,090
Working pressure, lb. gage	125

STOKERS

Manufacturer	American Engineering Co.
Type	Taylor 6-retort underfeed
Number	2
Projected grate area, sq.ft.	98.4
Drive, Reliance d.c. motor, hp.	5
Motor speed, r.p.m.	400-1600
Control	Automatic regulation of both stoker and fan motors
Ashpits	Baker-Dunbar-Allen Co.

FORCED-DRAFT FANS

Manufacturer	Buffalo Forge Co.
Type	Double Duplex Conoidal
Number	2
Capacity, cu.ft. per min.	35,000
Drive, Reliance d.c. motor, hp.	60
Motor, speed, r.p.m.	600-1200

STACK

Builder	Alphons Custodis Chimney Construction Co.
Type	Radial brick
Height above grates, ft.	200
Diameter at top	9 ft. 6 in.

BOILER-FEED PUMPS

One centrifugal, turbine-driven	DeLaval Steam Turbine Co.
Capacity, gal. per min.	250
One duplex, 14x8½x12 in.	Worthington Pump & Machinery Corp.
Capacity, gal. per min.	53½

HEATERS

One feed water, open type	Warren Webster & Co.
Capacity, lb. per hr.	90,000
One domestic hot water, closed type	Griscom-Russell Co.
Capacity, 50 to 193 deg. F., gal. per hr.	18,000
Hot water pump, centrifugal, 3-in.	DeLaval Steam Turbine Co.
Capacity, gal. per min.	300
Drive, Reliance motor, hp.	7½

COAL HANDLING

Capacity, tons per hr.	50
Apron feeder, 30 in.	Stephens-Adamson Mfg. Co.
Drive, induction motor, hp.	5
Crusher, single roll, 30x30-in.	Jeffrey Manufacturing Co.
Drive, induction motor, hp.	30
Pivoted bucket carrier, 18x24-in.	Stephens-Adamson Mfg. Co.
Drive, induction motor, hp.	15
Traveling weigh larry, 1 ton	Stephens-Adamson Mfg. Co.

TURBO-GENERATORS

Manufacturer	DeLaval Steam Turbine Co.
Number of turbines	2
Type	Geared, bleeder
Rating, kw.	500
Speed, r.p.m.	5,000
Generator, 125-volt, d.c.	Crocker-Wheeler Co.
Speed, r.p.m.	600
Condensers	Union Steam Pump Co.
Type	Three-pass surface
Surface, sq.ft.	2,150
Circulating pumps, centrifugal	Union Steam Pump Co.
Capacity, 10-in., gal. per min.	2,600
Drive, Reliance motor, 750 r.p.m., hp.	40
Condensate pumps, centrifugal	Union Steam Pump Co.
Capacity, 1½-in., gal. per min.	52
Drive, Reliance motor, 1,750 r.p.m., hp.	5
Air pumps, steam-jet	Wheeler Condenser & Engineering Co.
Capacity, cu.ft. per min.	10
Oil purifier, centrifugal	DeLaval Separator Co'
Traveling screen, 72 in., 20 ft. 6 in. centers	Link Belt Co.

MISCELLANEOUS MECHANICAL EQUIPMENT

Traveling crane, 7½ ton	Northern Engineering Works
Diamond soot blowers	Power Specialty Co.
Feed-water meters, venturi	Builders Iron Foundry
Copes feed-water regulators	Northern Equipment Co.
Industrial car	Koppel Ind. Car & Equipment Co.
Blowoff valves	Babcock & Wilcox Co.
Blowoff plug cocks, Gato	A. W. Cadman Mfg. Co.
Safety valves (Consolidated)	Manning, Maxwell & Moore, Inc.
Reducing valves	A. W. Cash Co.
Multi-ported b.p. valves	H. S. B. W. Cochrane Corp.
Automatic non-return valves	Schutte & Koerting Co.
Globe valves	Jenkins Bros.
Gate valves	Jenkins Bros.
Draft gages	Precision Instrument Co.
Steam-pressure gages	Ashcroft Mfg. Co.
Piping	Parke, Davis & Co.
Pipe covering	Johns-Manville, Inc.

MISCELLANEOUS ELECTRICAL EQUIPMENT

Switchboard, 7 panel	Mutual Electric Co.
Ammeters and voltmeters	General Electric Co.
Circuit breakers	Cutter Electrical & Mfg Co.

3,600 r.p.m. The unit is served by a surface condenser whose auxiliaries, consisting of vacuum, condensate and circulating pumps, are mounted on the same shaft and driven by a small turbine. The main turbine was designed to operate on exhaust steam at a pressure of 5 lb., which may be supplemented with high-pressure steam from the boilers to carry the load. While ordinarily this unit will be held in reserve, it is available at any time to take any surplus exhaust steam, drawing, if need be, from the bleeder turbines or from the boilers to carry the alternating-current load. This is generally supplied, however, from the main direct-current units through a 200-kw. motor-generator set, converting 125-volt direct current into 440-volt alternating current or vice versa. With the mixed pressure unit it is possible to convert two-thirds of the capacity to direct current and use the remainder of the generator capacity to carry the alternating-current load. Thus the entire plant layout has great flexibility, insuring continuity of service and economy, owing to the complete utilization of all exhaust steam.

Only one of the engine units was retained. This is a 12x16-in. 4-valve engine directly connected to a 125-volt 140-kw. direct-current generator, the speed being 250 r.p.m. This unit will be used to carry the load after business hours. Its economy is low, but this factor is not of importance with full use for the exhaust steam.

The electrical construction in the plant is new and of modern, substantial construction. The switchboard is on the turbine-room floor, but the rest of the equipment is in the basement, the entire south bay having been reserved and divided off by a wire screen partition. The main bus, consisting of positive, negative and equalizing bars made of 4x$\frac{1}{4}$-in. copper varying from 4 to 10 sections, according to the load to be carried, is suspended from the basement ceiling and extends practically the whole length of the room to serve all the machines. Each generator is protected by a circuit breaker provided with a solenoid for remote control from the switchboard and is also arranged for manual operation. The rheostats are in the basement and, as in the case of the circuit breakers, are equipped for remote control. Cables connect the generators to the circuit breakers, but with this exception there are no wires in the turbine-room basement. Copper straps lead from the main bus to the positive and negative switches of the power circuits on the switchboard, and from the opposite poles of these switches copper straps run down to the fuse panels located on a gallery in the basement. Directly under and behind this gallery is a tunnel giving access to the conduits carrying the feeder cables distributing power to the works. From this tunnel the cables are carried up through the gallery floor and are attached to the fuse panel through potheads.

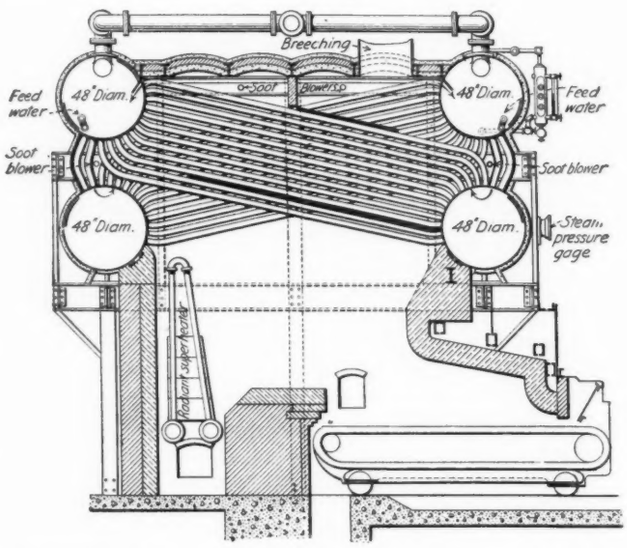
Power is distributed through 25 pairs of 1,000,000-circ.mil cables wrapped in $\frac{1}{32}$-in. paper and encased in $\frac{3}{32}$-in. lead. These cables are underground, being laid in fiber conduit set in concrete, and carry electrical energy to ten distributing boards located in various parts of the plant. The switchboard, which is of black, oil-finished slate, contains eight panels, 90 in. high by 30 in. wide. It is equipped with the usual instruments and control mechanism for supply and feeder circuits.

The entire work of making over the plant was carried out under the supervision and direction of the engineering staff of Parke, Davis & Co. Smith, Hinchman & Grylls, of Detroit, were the consulting engineers.

Burton Four-Drum Duplex Boiler

Some time ago the Burton boiler was described in these columns. It will be remembered that the boiler had two cross-drums, set front and back, in which criss-cross tube sections alternately terminated. At the opposite ends of the sections the tubes entered headers connecting with the drums. Since the manufacture of this boiler was taken over by John Mohr & Sons, South Chicago, Ill., Mr. Burton has revised the design principally by replacing the tube headers with drums of the same dimensions as the steam drums and placed on the same vertical center lines. The arrangement of the new four-drum duplex boiler is shown in the illustration.

Authorities consider the design an improvement over the two-drum boiler. By the elimination of machine work the construction has been simplified and the



SECTIONAL VIEW, SHOWING ARRANGEMENT OF NEW FOUR-DRUM DUPLEX BOILER

first cost lowered considerably. With the four drums the volume of water is increased with less variation in the water level. The setting dimensions have not been altered, the tubes have the same incline, and, as before, the water circulation traces a figure 8, with steam release in the two upper drums. After the water passes down through the circulating tubes from upper to lower drums, there is a sharp reversal of flow upon entering the tube sections, so that much of the sediment content drops out and settles to the bottom of the lower drums, where the circulation is not so active, to be blown out from either drum through the usual blowoff connections. With access to the tubes from all four drums cleaning is made easier. In the upper half of each tube section the curvature of the tubes is the same as in the lower half, so that corresponding tubes may be interchanged.

Gas baffling with fire tile is as indicated. Where employed, superheaters are of the radiant type, set back of the bridge wall. The boiler is supported on structural steelwork, has a standard firebrick roof, and the brick walls of the setting insulated by asbestos are steel inclosed.

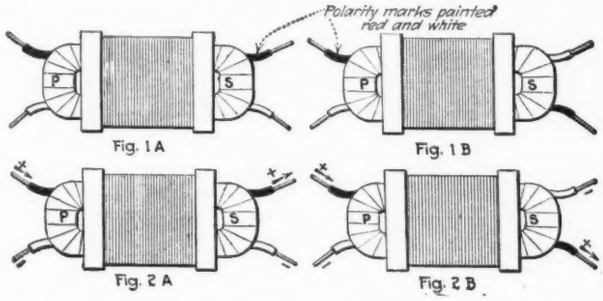
The efficiency of a mercury boiler and turbine is comparable with that of a Diesel engine.

How To Check Instrument Transformer and Meter Connections

Polarity of Instrument Transformers—Connecting Up Wattmeters—Polarity of Polyphase Circuits—Installing Meter Wiring in Conduit—Use of Multi-Colored Cable for Wattmeter Connection

By VICTOR H. TODD
Engineer, Westinghouse Electric and Manufacturing Company

WHEN wiring up wattmeters and watt-hour meters to register the electric power in a plant, it is necessary to connect the current and potential coils so that the instantaneous polarity, or the flow of current at any instant, is in the proper direction to produce a positive deflection or rotation of the meter. On a single-phase circuit without transformers this is usually quite easy to accomplish, but when the wiring is complicated by transformers, and when the meters are located at considerable distance from the lines, with the meter wiring often running through



FIGS. 1 AND 2—INDICATE POLARITY MARKING ON INSTRUMENT TRANSFORMERS

conduit, it becomes necessary to know the "polarity" of the transformers and the meters, as well as to identify readily any one of the connecting wires.

Meaning of Transformer Polarity

With direct current it is assumed that the current flows from + to —; so if the polarity of a piece of apparatus is given the direction of current flow can be determined, and conversely, if the direction of current flow is given the polarity can readily be determined. The same rule holds true in alternating current, although both the polarity and direction of current flow reverse perhaps 50 to 120 times per second, depending on the frequency of the circuit. Therefore, in order to find out the relation of polarity and current flow in alternating-current diagrams, we pick out any particular instant and label the polarity at that instant, the "instantaneous polarity" with a + or —, and label the current at that instant, the "instantaneous direction of current flow," using a small arrow to denote the direction. In the accompanying diagrams all the + signs may be changed to — and all the arrows reversed, yet the results will be absolutely the same.

Consider for the first case, an ordinary potential transformer. These devices usually have two primary and two secondary leads, and one of each will be painted red or white. The diagrams will appear somewhat like Figs. 1*A* or *B*. Since the primary *P* consumes power, if it is assumed that the polarity mark is +, then the direction of current at that instant will be as shown by the small arrows in Figs. 2*A* and *B*. The secondary *S* is acting like a generator of power, so with this polarity mark + the direction at that instant will be as shown by the little arrows on the secondary side. The same method may be expanded to a complete diagram and take the form of Fig. 3, which shows a potential transformer connected to a voltmeter.

Polarity of Current Transformers

When the current transformers contain a wound primary, thus having a total of four leads, the polarities are just the same as for a potential transformer. Many current transformers, however, have a hole through which a line wire may be passed to form the primary. These transformers will have a white or red spot painted on one side of the transformer at the end of the hole, thus denoting that at the instant when the current flows through the line wire from the polarity marked side to the opposite side, then the secondary current will leave the polarity marked lead and flow to the opposite lead. Fig. 4 shows the relation between polarity marks and current flow in this type of transformer.

Connecting up a Wattmeter

Examining the instructions furnished by the manufacturer, a wattmeter diagram may be found similar to Fig. 5, and in order to most easily and correctly connect this in the circuit, it should be marked with the instantaneous polarities and direction of current flow. Assuming that the right-hand wire is + at a particular instant, then the small arrows in Fig. 6 will indicate the direction of current flow at that instant in both current and potential windings. Note that this manufacturer places polarity marks on the opposite ends of the transformers. If these polarity marks do not occur in the diagrams furnished, it may be assumed that these marks are both on the same end. Thus if Fig. 5 did not designate polarity marks, the instantaneous directions of current flow would be those of Fig. 7 rather than Fig. 6.

Polyphase-Circuit Polarities

Two-phase circuits may be treated exactly like two single-phase circuits, whether they employ four wires or three. If the two phases employ a common wire, then it may have two sets of arrows to show the current flow. These need not interfere even if pointing in opposite directions, as that condition simply means that the wire is carrying only the difference of two

currents and does not interfere with the polarity or instantaneous markings in the least.

Three-phase circuits are also marked by assuming the polarities at any instant. There may be twelve distinct sets of instantaneous directions of current flow in a three-phase circuit, any one of which will work correctly, but for the sake of uniformity the instant usually assumed is when the current is flowing toward the load in the two outside wires and returning in the middle wire or neutral.

Consider first the manufacturer's diagram, Fig. 8, which is for a polyphase wattmeter. It is assumed that the outside wires are + and the middle wire —. Then the instantaneous directions of current flow are as indicated in Fig. 9.

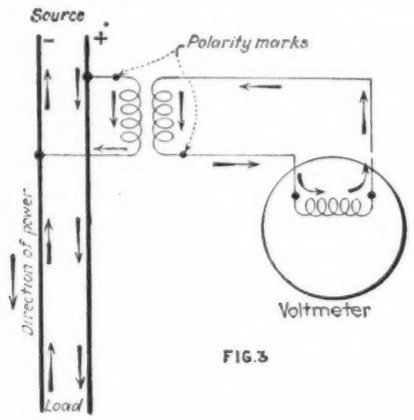


FIG. 3

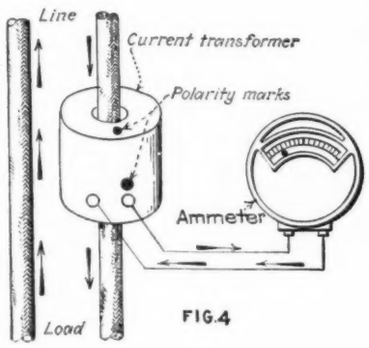


FIG. 4

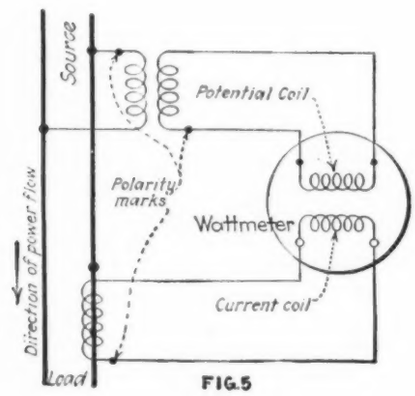


FIG. 5

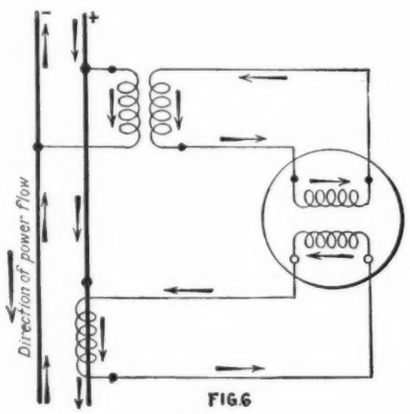


FIG. 6

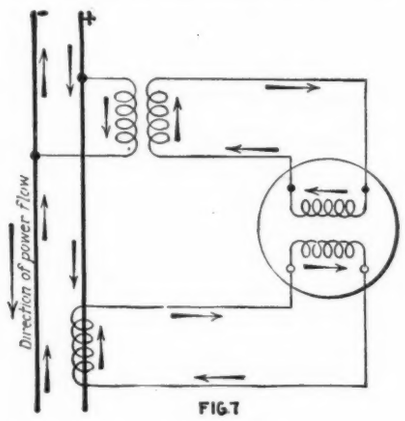


FIG. 7

FIGS. 3 TO 7—SHOW RELATION BETWEEN POLARITY MARKING AND METER CONNECTIONS

Fig. 3—Instantaneous direction of current flow in a potential transformer. Fig. 4—Instantaneous direction of current flow in a current transformer. Fig. 5—Diagram for single-phase wattmeter and transformer connection with polarity marks indicated. Fig. 6—Same as Fig. 5, with instantanous direction of current flow indicated. Fig. 7—Instantaneous direction of current flow when polarity marks are not given

Importance of Instantaneous Markings

For the foregoing simple cases, perhaps other systems of connection identification could be devised to work as well, and in fact the experienced instrument man would often not even require a diagram to hook up a meter correctly. But the greatest application of this system lies in laying out wiring diagrams for switchboards where perhaps ammeters, relays, power-factor meters and other devices may be all connected to the same transformers. Then the checker will set before this complete switchboard wiring diagram and, starting at the polarity mark on a transformer, follow the line through its maze of wiring, putting a little arrow at short intervals as he proceeds, until finally the line ends at the opposite side of the transformer.

As an example of this consider Fig. 10, which is a diagram of an alternating-current panel with a wattmeter, ammeter and oil switch. For the potential circuit, first start at *A* and the line goes through the fuse, potential coil of wattmeter, fuse and back to *B*. Again starting at *C*, the path is through the fuse, other potential coils, fuse and back to *B*. Starting at *D*, of the current transformers, the path must ultimately come back to *F*. Therefore, from *D* the circuit is through the current coil of the wattmeter, which must correspond to the same phase as the potential coil, then over through the oil-switch trip coil, through the common wire and the ammeter back to *F*. In a similar manner, starting at *E*, the circuit is through the other current coil of the wattmeter, the other trip coil, ammeter and back to *F*. It will be noted that there is a common connection between the common connections of both the current and potential transformers, but this is for protective purposes and is usually grounded and does not carry any current in normal operation.

Many times wiring must be run in conduit, as the transformers may be located at considerable distance from the switchboard or instruments. In such cases it is preferable to run two wires from the current transformers and make the common connection at the meter rather than at the transformers. A wattmeter diagram like Fig. 9 would then take the form of Fig. 11, where the wires are shown entering the conduit at the transformers and leaving at the meter.

Identifying the Wires

Care must be used in identifying the wires as they enter and leave the conduit. One way is to ground one wire to the conduit at one end, and then at the other end pick out with a magneto, bell and battery or megger, the wire that gives a circuit through the conduit. Mark both ends with paint or tags so they may be easily distinguished. Then ground the next wire and identify it at both ends, and so on. This process is rather a long drawn out one, and there is always

the danger of getting the markings mixed, which everyone familiar with this class of work knows. Furthermore, if the devices are disconnected, then it is a case of seeing that the wires are properly marked so that they may be connected up again correctly, and this is always a source of trouble. To overcome this difficulty, it is becoming general practice to use different colored wires for meter and transformer connections.

Use of Multi-Colored Cable

Perhaps the easiest and best way to identify meter and instrument wiring whether it be in conduit or not, is to use wire with various-colored insulations. Cables may be obtained with either 2, 3, 4 or 7 different

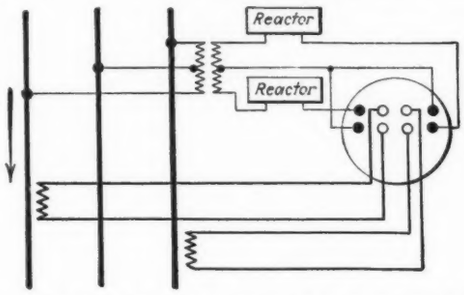


FIG. 8—MANUFACTURER'S DIAGRAM FOR POLYPHASE WATTMETER CONNECTIONS

colored wires under one covering. For polyphase wattmeter work it is best to employ a 4-wire cable for the current and a 3-wire cable for the voltage. Many firms use 7 conductors for this, but often the potential transformers are located at some distance from the current transformers, thus entailing considerable skinning of insulation and waste of cable.

Now if a polyphase watt-hour meter is to be connected to transformers with the wiring in conduit,

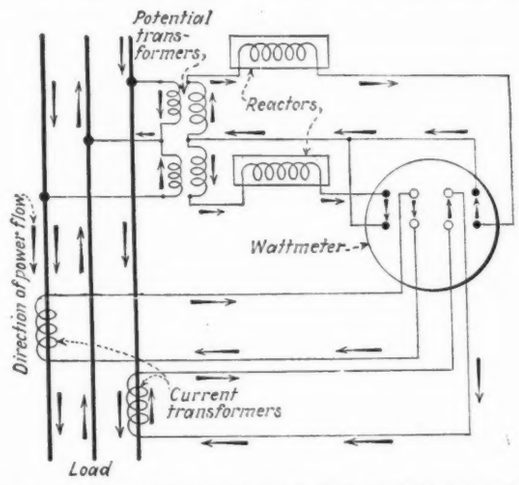


FIG. 9—SAME AS FIG. 8 BUT WITH INSTANTANEOUS DIRECTION OF CURRENT GIVEN

the diagram would appear like Fig. 11, where the instantaneous polarities, directions of current flow and colors of the wires are clearly marked.

This marking has been standardized by a large central station, and when meter wiring is encountered, every meterman can tell at a glance just which wires are potential and which are current; which wires feed and which return; and in this way it is easy to connect the meter correctly, and if one were connected wrongly, it would soon be detected.

In Figs. 8 and 9 reactors are shown in series with the potential coils of the wattmeter. The only time resistors are used in series with the potential circuit of a wattmeter or watt-hour meter is when the potential circuit of the meter is free from inductance, as in the dynamometer type. Meters of the induction type have high inductance in the potential circuit, conse-

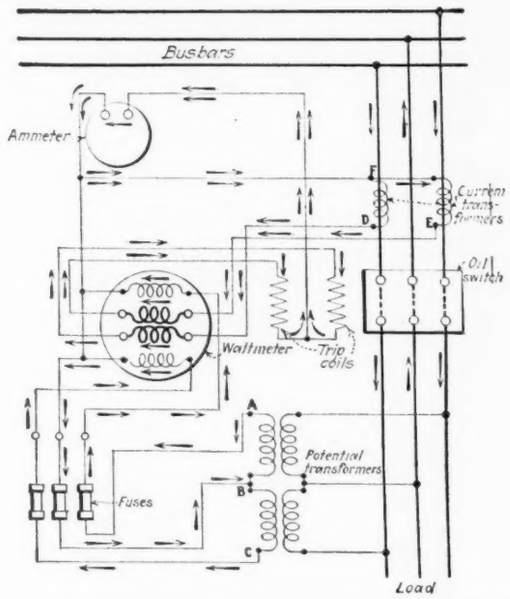


FIG. 10—AMMETER, WATTMETER AND TRIP COILS OF OIL SWITCH CONNECTED TO SAME TRANSFORMERS

quently must have a reactor in series to cause the current to lag sufficiently to give 90-deg. displacement between the current and potential fluxes. A resistor would tend to throw the potential current in phase, and the meter could not be calibrated on varying power factors. The meter and reactors are calibrated as a unit and must not be confused with multipliers. It is

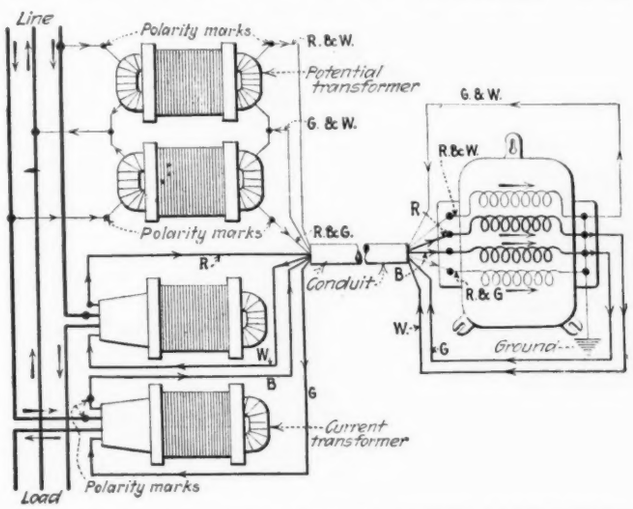


FIG. 11—SHOWS USE OF MULTI-COLORED CABLE FOR CONNECTING UP METERS

R. = red; W = white; B = black; G = green; R & W = red and white; R & G = red and green, and G & W = green and white.

impractical to build a meter with a reactor multiplier, as such a reactor must have exactly the same characteristics as the potential circuit of the meter, and this is done only in rare cases.

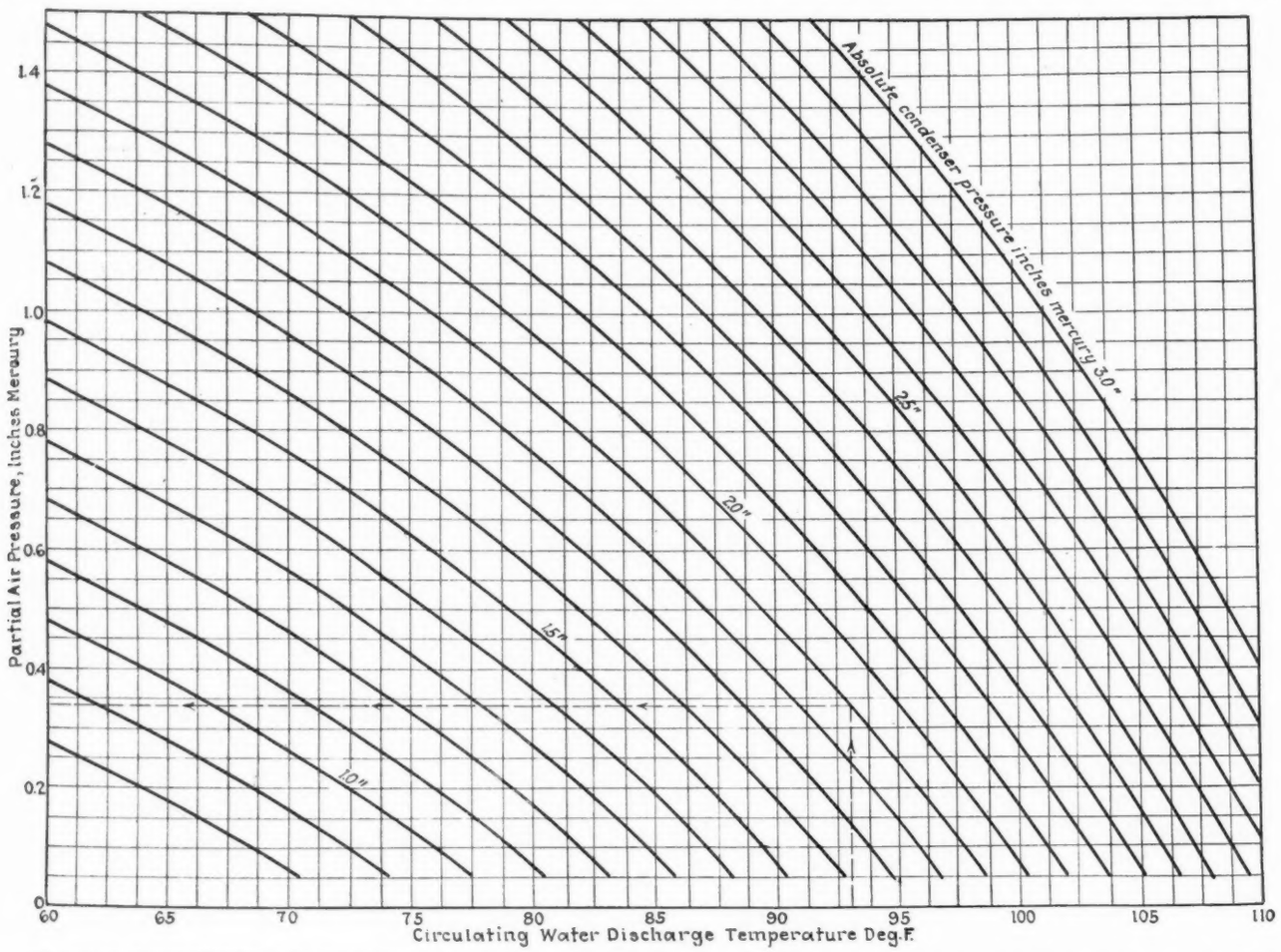
Determining Efficient Operation and Causes of Low Vacuum in Surface Condensers

By S. THOMAS

Excessive air leakage is quickly found by applying operating readings to the accompanying chart. Checking the proper amount of cooling water and the condition of tubes is discussed.

FREQUENTLY, the economy of a power plant can be improved considerably by increasing the efficiency of the condensers. In many plants the men in direct charge are not familiar with condenser calculations and therefore cannot thoroughly check their performance. Also at the season of the year when the vacuum is gradually decreasing owing to warmer circulating water, a discussion of the causes of low vacuum in surface condensers is always of interest.

Probably the most common cause of low vacuum is air leakage. This causes a certain amount of air pressure in the condenser, which is termed "partial air pressure." The true partial air pressure is determined by subtracting the vapor pressure of water at the temperature of actual condensation. Theoretically, the vapor pressure corresponding to the temperature of the vapors inside the condenser should be used, but it is extremely difficult to determine such temperatures accurately. It is more practicable and gives very valuable information, to assume that the vapor pressure corresponds to the temperature of discharge cooling water, and then allow a reasonable value for calculated partial air pressure.



PARTIAL CONDENSER AIR PRESSURE AS BASED ON DISCHARGE CIRCULATING-WATER TEMPERATURE AND THE NET INTERNAL VAPOR PRESSURE

This air pressure can be obtained from the accompanying chart without any calculations. The discharge-water temperature is read from the thermometer. The condenser pressure is the difference between the barometer and the steam-chamber mercury-column readings. To determine the partial air pressure from the

chart, locate the discharge temperature on the lower scale and go vertically upward as indicated by the broken line until you come to the curve that represents the condenser pressure. Move horizontally to the left as indicated and read the partial air pressure on the left-hand vertical scale. In the case taken with a discharge temperature of 93 deg. and a condenser pressure of 1.90 in., obtained from a barometer of 29 in., and mercury column connected to the exhaust-steam path of 27.1 in. The partial air pressure is 0.34 in. as obtained from the chart.

Condition of Tubes Affects Rate of Heat Transfer

If the condenser tubes are dirty, the heat-transfer rate will be reduced and the vacuum will be decreased. This causes a higher partial air pressure to be indicated. It should, therefore, be understood that if the condenser is dirty, the partial air pressure will be too high even though the air leakage is at a minimum. This condition is generally indicated by a rise in the temperature of the condensate. With best operating conditions the partial air pressure should be about 0.3 in. for turbines, but a higher figure is permitted for engines.

An insufficient supply of circulating water will decrease the tube velocity and reduce the vacuum. The quantity of water pumped should be calculated and the ratio of the pounds of circulating water to one pound of steam condensed should be determined.

$$Q = \frac{S \times L \times 950}{R \times 8\frac{1}{3} \times 60} = \frac{S \times L \times 1.9}{R} \qquad (1)$$

$$\text{Ratio} = \frac{Q \times 8\frac{1}{3} \times 60}{S \times L} = \frac{Q \times 500}{S \times L} \qquad (2)$$

Combining (1) and (2)

$$\text{Ratio} = \frac{S \times L \times 1.9 \times 500}{S \times L \times R} = \frac{950}{R} \qquad (3)$$

where

Q = Total quantity of cooling water, gal. per min.;
S = Steam rate of turbine at load carried, lb. per kw.-hr.;
L = Load in kilowatts on turbine;
R = Temperature rise in circulating water, deg. F.

The 950 is the figure generally used for the B.t.u. in one pound of exhaust steam. With cold water such as is obtained during the winter months, a ratio of about 45 lb. circulating water per pound of steam condensed is generally satisfactory, while with warm water during the summer months, a ratio of 75 or more is required. Of course circulating water should not be pumped to such an excess that the power required by the pump will more than offset the gain obtained, due to the increased vacuum. Efforts should be made to improve the vacuum only when a higher vacuum will improve the economy of the plant as a whole.

Example: A turbine whose steam rate is 12 lb. per kw.-hr. is operating at 20,000 kw. load in the summer. The rise in temperature of circulating water through the condenser is 15.2 deg. F. Find the total cooling water and the ratio of pound of cooling water per pound of steam condensed.

From equation (1)

$$Q = \frac{12 \times 20{,}000 \times 1.9}{15.2} = 30{,}000 \text{ g.p.m.}$$

From equation (3)

$$\text{Ratio} = \frac{950}{15.2} = 62.5$$

This ratio is somewhat lower than recommended for summer operation. The circulating water should be increased, if convenient, until this is nearer 75.

The higher the vacuum the less the steam rate of the turbine up to a certain point called the limiting vacuum. This is true because the steam passages in the turbine are designed to take care of a certain maximum volume of steam, and when that volume has been reached, further expansion cannot take place. The value of the limiting vacuum can be obtained from the manufacturer, as it varies with different machines and with different loads on the same machine. However, it is nearly always well above the vacuum generally maintained, especially if the machine is lightly loaded.

A special set of condenser readings should be taken every day or at least once a week at a time when the operating conditions are normal. The partial air pressure, the absolute condenser pressure and the difference between the discharge condensate temperatures should be plotted. The present and the past performance at the same load can be compared, and any sudden or gradual changes for better or worse are plainly shown. This time of the year, when the circulating water is getting warmer, the condenser pressure is bound to increase, which is unpreventable, but any increase due to higher partial air pressure can and should be prevented.

Electrical CO_2 Meter and Recorder

Both chemical-absorption and electrical type CO_2 meters have been used successfully. The S. & H. CO_2 meter, which is marketed by the Bacharach Industrial Instrument Co., Pittsburgh, Pa., is of the latter type and makes use of the physical property of heat conduction of the flue gases. The arrangement of the meter is shown diagrammatically in Fig. 2. The "tester" consists of two sets of metal blocks, one set containing chambers *A* and the other chambers *B*, Fig. 1. In the center of each chamber is a thin platinum wire, having

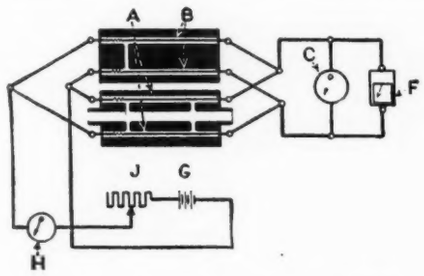


FIG. 1—DIAGRAM OF CO_2 TESTER

at one end a small platinum-iridium spring for keeping the wire always central, regardless of heat expansion. The flue gas passes through measuring chambers *A*, where *B* are the comparison chambers, containing air at room temperature. The electrical system is arranged in a Wheatstone bridge circuit, of which the four branches are the four platinum wires in the two blocks. Across the midpoints of the bridge is connected the sensitive indicating galvanometer *C*. If desired, the recording galvanometer *F*, which may be placed at any reasonable distance from the measuring instrument, can also be connected into the circuit. Electrical energy is obtained from a small storage battery *G* through a variable resistance *J* which is adjusted to give constant current through ammeter *H*.

Fig. 2 shows the general arrangement of the meter with its accessories. The flue-gas sample is drawn

through the tube *A* to cooler *B*, in the outer jacket of which circulates water going to the aspirator *G*. From the cooler the gas goes through the soot filter *C*, then through the secondary indicating filter *E* and to the measuring instrument shown diagrammatically in Fig. 3. From this tester the gas passes to the aspirator *G*, Fig. 2. The latter is connected with a cock *2* to adjust the suction to about a 1-in. water column above the flue draft, thus insuring a practically constant rate of gas flow. For example, if the flue draft equals a ½-in. water column, the manometer *F* should indicate 1½ in. Under these conditions the gas flow will be fast enough to insure a reasonably quick change of sample, but at the same time the flow will not be so fast as to influence the heat transfer from the wires. The electrical connections lead to the galvanometers, indicating and recording. Indicating filter *E* in Figs. 2 and 3 is used to indicate or warn when the main filter is no longer working. *D*, Fig. 2, is a throttle to provide a sufficient pressure drop so that manometer *F* can indicate a clear reading for the adjustment of the gas velocities through the system. There is provided on the right side of the tester, Fig. 3, a small screen and some wadding to protect the main conduit of the meter against any spray of the mixture of water and glycerin contained in the manometer *F*.

The flue gases consist of carbon dioxide (CO_2), carbon monoxide (CO), oxygen, nitrogen and water vapor, with traces of other gases. Nitrogen, oxygen, carbon monoxide and air all have practically the same heat conductivity, but CO_2 has 40 per cent less conductivity and water vapor a conductivity about 30 per cent greater than that of air. The air in the comparison chamber is kept free from water vapor by the presence of hydroscopic chemicals, and the flue gases having passed through a cooler which also acts as a drier, contain a very small but practically constant quantity of water vapor, hence the only variation occurring in the

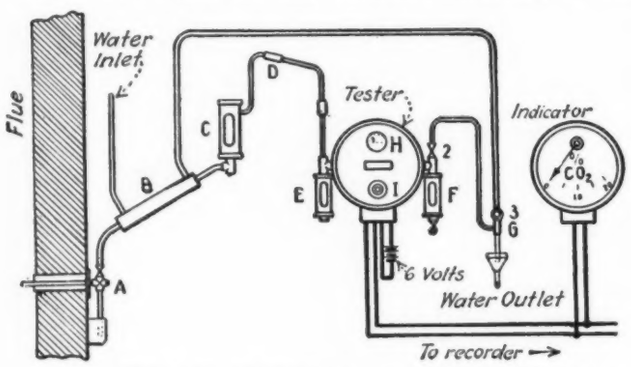


FIG. 2—GENERAL ARRANGEMENT OF CO_2 METER AND ITS ACCESSORIES

heat conductivity of the gases depends directly on the percentage of CO_2 in the flue gas.

As the electric current flows through the platinum wires, the heat generated in them is transmitted through the gases to the walls of the chambers. The gases in *A*, containing CO_2, transmit the heat less readily than the air in *B*, and the wires in *A* become hotter than the wires in *B;* their resistance therefore increases, unbalancing the circuit and causing a deflection of the galvanometer to an extent depending on the percentage of CO_2 present. The galvanometer is calibrated to read directly in percentage of CO_2. Variations of room temperature influence the two systems of wires *A* and *B* in the two metal blocks in the same way and therefore do not affect the proper indication of CO_2, as the electric circuit of the Wheatstone bridge is unbalanced only by the difference in temperature between wires *A* and *B* established by the different heat conductivity of the air in the comparison chambers and the flue gas in the measuring chambers.

In this meter time lag is practically eliminated. The interval between the drawing of the gas into the

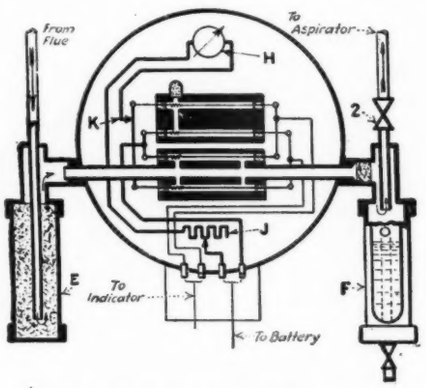


FIG. 3—SHOWS THE RELATION OF THE DIFFERENT PARTS IN THE CO_2 TESTER

sampling tube and the indication of its CO_2 content does not exceed two minutes. The accuracy of the indication is guaranteed to be within $\pm\frac{1}{2}$ per cent of CO_2.

This meter has also a more general application; for instance, in determining the amount of hydrogen in producer gas. Its action in this case depends on the high conductivity of hydrogen, which is seven times that of air. For such use the meter is calibrated in percentage of H_2, for a given reasonably average percentage of CO_2 in the gas sample.

An electrical type of CO meter has been developed, which can be used simultaneously with the CO_2 meter. It is somewhat similar in construction to the CO_2 meter, but operates on a different principle.

Data on Refractories

The accompanying table (prepared by Frank G. Parker, combustion engineer) is taken from the August issue of *The Log*, the monthly publication of the American Society of Marine Engineers.

Material	Density, Lb. per Cu. Ft.	Specific Heat, Referred to Water	Conductivity, B.t.u. per Hr., per Sq. Ft. per In., per Deg. F.	True Porosity per Cent of Volume
Maphite	79.50	0.210	7.58	6.36
Hitempite	140.00	0.252	11.00	45.7
Thermolith	156.00	0.200	16.55	26.4
Quick patch	131.00	.....	11.60	.....
Plibrico	131.50	0.257	13.65	30.8
Refracto coat	128.00	.....	69.40	38.3
Magnesia brick	125.00	0.324	20.60	41.0
Bauxite brick	118.00	.....	9.58	38.4
Alundum brick	149.00	.....	7.28	22.1
Carborundum brick	128.00	.....	66.70	30.6
Chromite brick	196.00	0.174	16.85	21.3
Feldspar	.....	.....	16.05	.....
Gas-retort brick	.....	.....	11.00	.....
Firebrick	144.50	0.250	12.20	29.7
Graphite brick	112.00	.....	72.60	.....
Silica brick	98.50	0.290	5.81	42.9
Magnesite brick	.....	.....	48.90	.....
Sand	110.00	0.190	2.70	.....
Silo-cel brick	30.00	0.225	0.67	.....
Silo-cel brick	31.00	0.209	0.75	.....
Common building brick	118.00	.....	10.15	25.7
Insulbrix	36.00	0.190	0.84	.....
Asbestos	27.50	0.300	1.00	.....
J-M 26	130.00	0.254	11.92	.....
J-M 31	129.00	0.258	11.34	.....
Esso Bond 35	140.00	0.260	13.06	47.5

Finding a Use for Waste Wood

A DISCUSSION of the advantages of gas producers using waste products. Tests on producer-engine units. Gas analysis.

BY JOHNSTONE TAYLOR

ONE of the greatest advances made in the gas producer during recent years is its adaptation to the use of waste wood—in fact, any combustible waste. It is not always appreciated that, given the necessary quantity of such fuel, gas engines of considerable size can be operated at an astonishingly low cost. Where manufacturing processes produce large quantities of combustible refuse such as sawdust, spent tan, peat, waste cotton seed, coffee, rice and cocoa husks, mealie cobs, coconut shells, sugar-cane refuse, etc., the cheapest source of power is the waste-fuel producer and gas engine.

Several of the well-known gas-producer builders in England have turned their attention to the question,

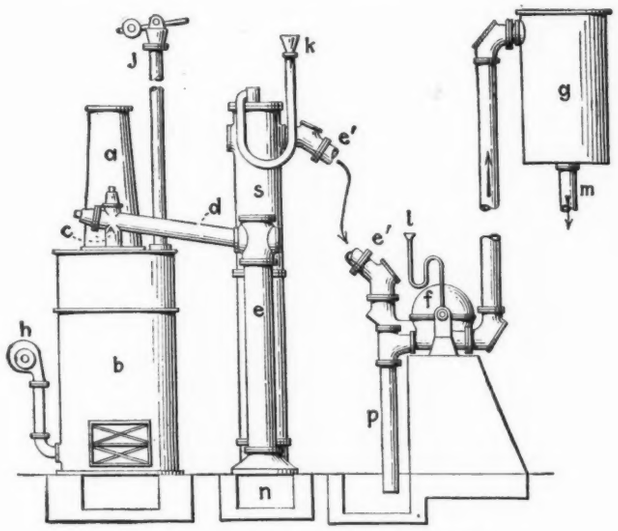


FIG. 1—WOOD-REFUSE PRODUCER

the Ruston, Crossley and National firms being in this list. The general arrangement of the Ruston system is shown in Fig. 1, while Fig. 2 is a section of the producer. To avoid too frequent charging, the fuel chamber *a* is made of large capacity. Before the fuel reaches the combustion zone of the generator, it passes down through the distilling chamber, Fig. 2, where, subjected to the heat of the surrounding gas, it gives off its volatile constituents, thus enriching the gas leaving the producer. The generator *b* is constructed of steel plate, firebrick-lined and has a fire grate of loose bars, which can be removed through the firedoors.

The fuel is fed directly into the fuel chamber, there being no slide valve or hopper. In place of leaving the generator by the usual single outlet, the gas is taken off at two or more points at the top of the generator by the vertical pipes *c* and passes through the main pipe *d* to the dust collector *e*, and leaving at the base enters the scrubber *s*. The outlets *c* are so arranged that an even draft is assured through the fuel at all points and under all conditions of load. The main pipe *d* is provided with scrapers by means of which dust and tar deposit can be removed at any time without interfering with production.

From the top of the scrubbers *s* the gas passes via pipe *e'* to a two-stage rotary tar extractor *f*, where the tar is thrown out before the gas reaches the sawdust scrubber *g*. From 6 to 8 gal. of water per brake-horsepower hour is required for cleaning the gas; the bulk of this water may be circulated through a cooler and filtered and used again, about 1 gal. per brake-horsepower-hour being required as makeup. The hand fan *h* is for the purpose of starting the fire, in conjunction with which is the blowoff valve *j*. The final suction line to the engine is shown at *m*. The water seal *n* at the base of the dust collector enables a goodly proportion of the tar to be deposited therein and withdrawn during the operation of the plant. The main tar-settling pipe is shown at *p*. This producer may be taken as typical of the type.

The National design does not differ much from the firm's orthodox pattern for coal fuel, but in place of the vaporizers, which are not required with refuse fuels on account of their inherent moisture, a large cast-iron dust catcher is fitted with a water spray for the purpose of partly cleaning and cooling the gas. Any deposit that is drawn over from the generator can be easily removed during operation through a water seal.

In some cases difficulty may be anticipated in a temporary failure of the supply of refuse fuel. Normally, a refuse producer, having no means of supplying steam to the fuel, which is an essential part of the production of producer gas from coal, and in some other details differing from a coal producer, is unsuitable for utilizing coal in case of emergency. The Crossley design provides for such a contingency by a specially designed stepped fire grate and an air-lock hopper.

When the fuel burned is pure refuse, operating costs, so far as fuel is concerned, do not exist. It may, however, occur that wood fuel must be cut and transported, and possibly purchased. Then the consumption of fuel becomes of some importance, as it will also be if the refuse is not always equal to the requirements. In the latter case a dual-operation plant is desirable, for which a stock of coal may be kept handy. The actual quantities of coal substitutes used per brake-horsepower-hour must, of course, be a nature of speculation until the plant has been tested under running conditions. The following figures, however, are given as the result of actual practice:

	Lb. per B. Hp. Hr.
Locomotive smokebox char	1½ to 2½
Coconut shells	1½ to 3
Rice husks	3 to 4
Mealie cobs	3½
Olive refuse	2
Sugar-cane refuse	2

Taking these commodities as pure waste products costing nothing, the operating costs of a 100-hp. plant, producer and engine running 2,500 hours a year, labor being reckoned at 50c. an hour and oil at $120, work out at $1,370 a year. The nearest approach to this is the cost of running a crude-oil engine of similar power, which, with fuel oil at 5c. per gal., comes to $2,170: while a coal-burning steam plant would cost $3,920 with

coal at $7 a ton; and electric power at 4c. per kw.-hr. would cost over $7,500. The refuse producer, therefore, as a commercial proposition cannot be surpassed. The approximate cost of a 100-hp. plant without engine is around $2,000; the engine would cost around $5,000.

The following data relate to a recently tested plant containing a refuse-fuel producer and a 140-b.-hp. twin horizontal engine.

Analysis: Ash, 0.58 per cent; moisture, 14; volatile, 75; fixed carbon, 10.42.

Duration of test, 8¾ hours.

Total wood consumption, 2,400 lb., consisting of 752 lb. chips, 300 lb. small wood bits and 1,348 lb. sawdust.

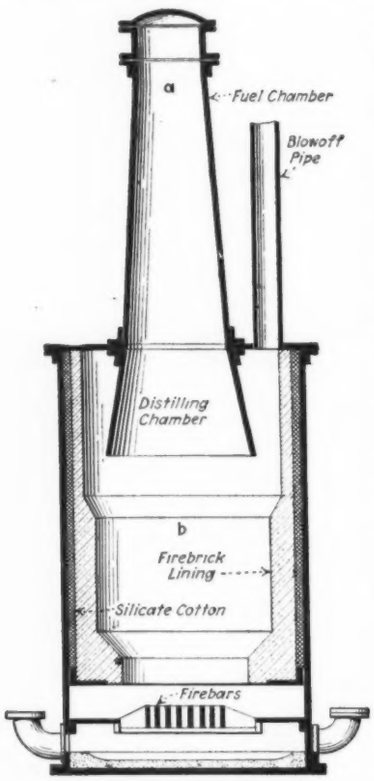


FIG. 2—CROSS-SECTION OF PRODUCER

Consumption per brake - horsepower-hour, 2¼ lb.

Load, brake-horsepower, 122.

Average gross calorific value of gas, 158 B.t.u.

Analysis of gas: CO_2, 12.8 per cent; O, 0.2; C_2H_4, 1; CO, 20; CH_4, 4; H, 9.3. per cent.

One of the most interesting plants using wood producers is that at Lonely Mine, Rhodesia, South Africa. This installation consists of four 350 hp. Crossley producers supplying gas to four multi-cylinder Premier engines. The guaranteed consumption of dry wood was as follows: **Full load, 2 lb. per** brake - horsepower-hour; ¾ load, 2.23 lb.; ½ load, 2.76 lb.; ¼ load, 3.50. The actual fuel consumption at 80 per cent full load worked out at 2.07 lb. per bhp.-hr. and 3.09 lb. per kw.-hr.

Concerning the exact composition of the gas produced from wood and wood refuse, little information is available, and the following data from this installation will be of interest. The average calorific value of the gas was found to be 161.5 B.t.u. per cubic foot, which may be looked upon as well above the average. Its composition was as follows: Carbon dioxide, 1.8 per cent; oxygen, 2.5; carbon monoxide, 22.9; hydrogen, 15.4; methane, 1.0; nitrogen, 56.4 per cent (by difference).

The enormous production of rice in eastern countries has brought to notice the possibility of the use of the husks for power production. This class of refuse has been used under boilers to some extent, but in common with similar fuels, the dampness mitigates against satisfactory results. In the process of gasifying the husk this is no detriment. The gas produced in the lower zone of the generator passes up through the superimposed green fuel and is thereby partly cooled and cleaned, while at the same time the fuel is getting dried. The vapor given off in this drying process passes away with the gas and enriches it. Rice husks can be looked upon as of considerable value as a source of cheap power so long as the producer is adapted to their use. The following figures relate to the performance of a 50 hp. engine and a producer using rice husks:

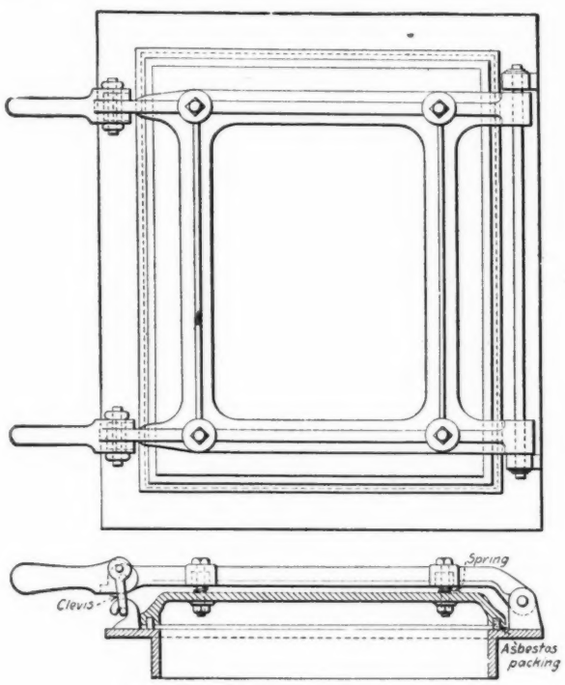
Analysis of fuel: Ash, 18.60 per cent; sulphur, 0.0; volatiles, 57.24; moisture, 10.00; fixed carbon, 14.11.

Duration of test, 6 hours; fuel consumed, 1,078 lb.; fuel per brake-horsepower-hour, 4¼ lb.; calorific value of gas, 138 B.t.u.

Analysis of gas: CO_2, 3 per cent; O, 0.4; H, 6.4; CO, 32.2; CH_4, 0.6; N, 57.4 per cent.

Brady Ashpit Door

An ashpit door that is self-seating, that will allow automatically for expansion and remain tight indefinitely, has been designed and patents applied for by H. G. Kinder, of the Brady Conveyors Corporation, 20 West Jackson Blvd., Chicago. The door, shown in the illustration, is made of cast iron in several standard sizes, lined or unlined as desired. The shape of the door proper is indicated in the sectional view. Around the seating edges it is grooved to receive hard asbestos braided packing. The door is suspended at



SELF-SEATING ASHPIT DOOR

four points from a rectangular hinge frame, and around each of the four stop bolts securing the door is a spiral spring placed between frame and door. The springs make the door self-seating and allow it to expand freely while still maintaining a tight joint at the seating surface. To allow for a permanent warp the packing may be adjusted as need be.

Cam levers attached to the hinge frame, in conjunction with clevises engaging hooks on the door frame, secure the door. The movement of the lever is out one-quarter turn to open the door and in to close it. When the lever is down, the center pin of the clevis falls outside that of the lever, so that the mechanism, when once clamped, will remain in that position.

Finding the Coefficient of Expansion and Compression on Indicator Diagrams

BY H. SCHRECK*

From time to time there have been published discussions on the valuation of indicator diagrams of Diesel engines, and a very elaborate work of this kind, by P. H. Schweitzer, appeared in *Power*, April 10 and 24.

Mr. Schweitzer's method of finding the exponent of expansion and compression should be used very cautiously since it is a difficult problem to draw correctly a tangent to a curve. To illustrate this point, there has been laid out in Fig. 1 an expansion curve *ab* using an adiabatic exponent $n = 1.4$. At point *X* a tangent was laid on the curve *ab* by the mirror method and the exponent n was determined as suggested by Mr. Schweitzer. It might be said that A_1B_1 is just as closely tangent as is *AB*, with the result that the exponent as measured on *OP* may be either 1.3 or 1.4. Of course we know that this curve was drawn with the exponent 1.4, but from the drawing, A_1B_1 seems even to be the more correct tangent; this would indicate that the curve *ab* had been drawn with an exponent of 1.3, which is not the case.

This simple illustration is to prove that with Mr. Schweitzer's tangent method almost any reading can be obtained on the actual indicator diagram. This fact is also more or less borne out by the curves shown in

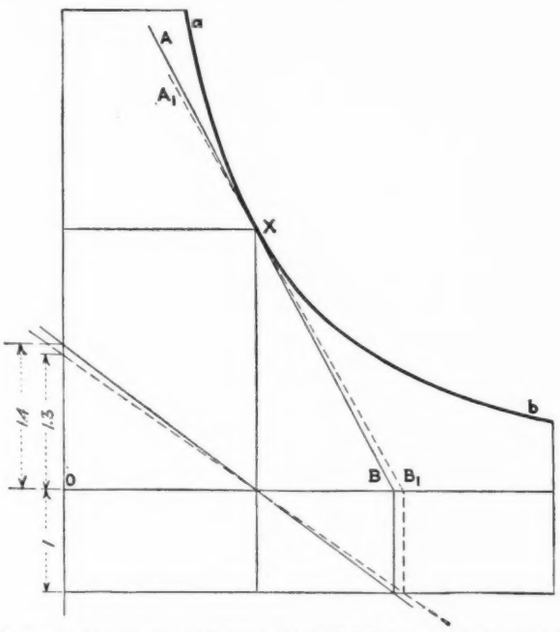


FIG. 1—SLIGHT CHANGE IN TANGENT ALTERS VALUE OF *n*

his discussion. Any curve that represents a physical change of condition cannot go up and down as these curves do. Furthermore, these curves of Mr. Schweitzer embrace another mistake in that the determination of the exponent of expansion has been carried on into the period while fuel is injected—that is, while outside heat is still being contributed—and during this period the change of state does not follow the law of an adiabatic curve.

In order to prove the advantages of the well-known method of determining this coefficient by plotting the values of cylinder volume *V* and pressure *P* on logarithmic paper, both methods have been employed in this

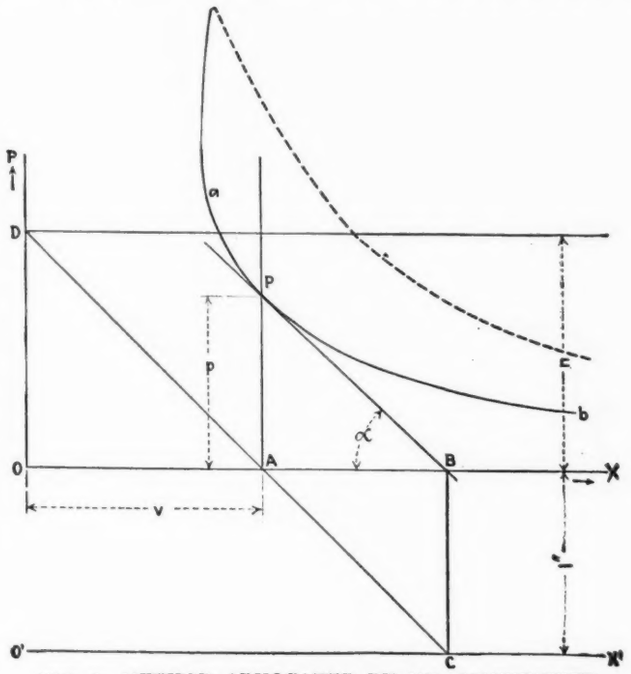


FIG. 2—METHOD ADVOCATED BY MR. SCHWEITZER

paper for investigating an actual Diesel diagram, Fig. 3.

The following readings of this indicator diagram were taken and listed in the table.

COMPRESSION

Schweitzer Method					Logarithmic Method	
1		2	3	4	5	6
Volume		Pressure,		v		
Station, Per Cent	V Cu.In.	Lb. per Sq.In. Abs.	α Deg.	$n = -tg\,\alpha$ p	α Deg.	$n = tg\,\alpha$
10	82.6	348	82.5	1.50	54	1.376
12.5	103	269	76	1.28	54.82	1.386
15	124	198	67.67	1.27	54.24	1.398
20	165	133	50.5	1.25	54.61	1.41
30	248	78	25	1.23	54.81	1.418
40	330	51	12.5	1.2	55	1.428
50	413	38	7.5	1.195	55	1.428
60	496	28	4.5	1.165	55	1.428
70	578	22	3	1.145	55	1.428
EXPANSION						
20	165	334	68	1.02	47.5	1.09
30	248	205	48	1.12	51	1.235
40	330	146	33	1.22	52	1.28
50	413	110	22	1.26	53	1.33
60	496	85	15	1.30	54	1.376
70	578	69	8.5	1.04	55	1.428
80	660	57	5.5	0.925	55	1.428
90	743	49	5	1.1	55	1.428

The volume of the cylinder in question, including its dead volume, is 826 cu.in., and this volume being divided into 10 equal parts, it results in volumes *V* as listed in column 1. The pressures *P* as read from the indicator diagram, are listed in column 2. The angle of the tangent at the various points was read by means of a mirror and the values are listed in column 3.

The Schweitzer method was then employed, and in order to avoid inaccuracies, the graphical method was dispensed with and the exponent calculated from the angle made by the tangent. For this purpose, Fig. 5 of Mr. Schweitzer's article is reproduced as Fig. 2.

*Works manager and chief engineer, Lombard Governor Co., Ashland, Mass.

The method of valuating n that is used is as follows:

$$\frac{OD}{OA} = \frac{BC}{AB} \text{ or } OD = \frac{BC \times OA}{AB} = \text{exponent } n$$

By substitution,

$$n = \frac{1 \times V \times tg\alpha}{P} = \frac{V}{P} tg\alpha$$

By this formula the value of n has been figured, keeping in mind that V, the volume, is in cubic feet and P, the pressure, in pounds per square foot. The results of this calculation of the exponent n are listed in column 4.

The exponent was then determined by plotting pressures and volumes on logarithmic paper, as shown in Fig. 4. The advantage of this method is readily seen for the reason that the slightest mistake in measurement or calculation will show up in these curves and curves will correct automatically any mistake. Tangents were laid at the various points, the angles made with the horizontal measured, and the tangent of these

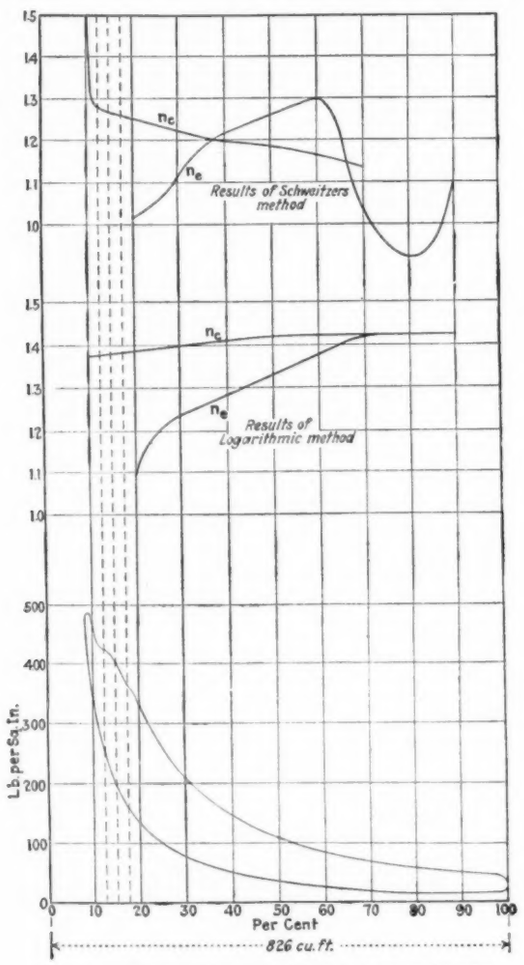


FIG. 3—INDICATOR DIAGRAM AND VALUES OF EXPONENT n

angles which are the numerical values of the exponent n were found. These values of n are listed in col. 6.

A word may be said about the results of estimating the exponent n by the two methods. First, as to the logarithmic method, the values check up very closely with the results of this test as laid down in the research paper from which the indicator diagram was taken.

The values of n determined by the Schweitzer method are far from the figures of the original research work; that is, for compression as well as for expansion. Furthermore, that the exponent of expansion is rising and falling is hardly possible even when conceding that the expansion curve is influenced by cooling condition of the cylinder, heat of the piston top, etc. Even then a gradual rising or falling would be the result

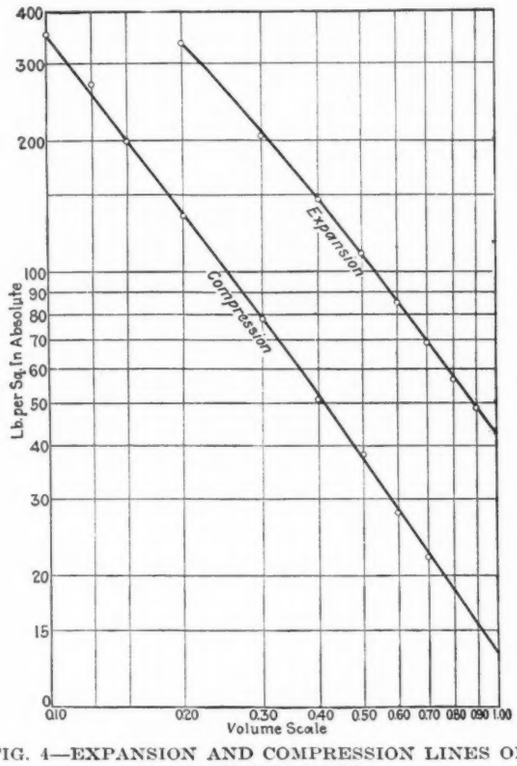


FIG. 4—EXPANSION AND COMPRESSION LINES ON LOGARITHMIC PAPER

because the conditions will certainly follow a fixed law or consistency.

The purpose of this discussion is to explain in a practical case how to find the exponents of expansion and compression, which, in the end, is the only means of interpreting the condition of an oil engine, and to arrive at conclusions which the indicator diagram in its original shape does not show. It is also intended to prove that the exponent curves, as illustrated by Mr. Schweitzer, are not possible and that his results are due to a method that is very difficult in its application, if at all possible. However, due consideration should be given to the elaborate work of Mr. Schweitzer, and all that the writer wishes to point out is that to use his method, extreme care must be taken and the values should be checked back by the use of logarithmic paper.

According to census figures recently issued there were 4,531 ice machines in use in the United States in 1921 of which 4,008 worked on the compression system and 523 were absorption machines. Nearly 600,000 hp. is involved. The tonnage was about equally divided between raw water and distilled water, although the can ice predominates over plated ice in the ratio of 22 to 1. These figures apply to the manufacture of ice for sale and do not include ice plants in hotels, apartment houses, hospitals, etc., which in the aggregate account for a considerable tonnage.

Fuel Oil and Viscosity

By M. G. LANGHAM

FUEL OIL was for many years purchased by the barrel without any specification whatever. This arrangement was satisfactory when all fuel oils were of high gravity and sufficiently fluid at ordinary temperatures. When the heavier oils from the Southern, Western and Mexican crudes were put on the market, it became necessary to specify the kind of fuel oil because the heavier oils required entirely different equipment for combustion.

The gravity reading was introduced as a means of classifying the oil, because the gravity was, in a general way, an indication of the ease of atomization. It has not been satisfactory because of the difficulty of taking gravity readings of the heavy oils by the hydrometer, or even in the laboratory with more accurate equipment. Furthermore, the presence of water, carried in suspension by the heavy oils, affects the gravity reading and destroys the accuracy of the results.

Practically any kind of fuel oil can be burned under a boiler provided it contains enough volatile material to ignite readily, and is fluid enough to flow to the burners. This brings into consideration the very important characteristic of fluidity, or its reciprocal, viscosity. Some oils are sufficiently fluid to flow through all lines, pump valves and burners without heating, while others are so viscous that they must be heated in the storage tanks before they can be used at all. The viscosity of the oil determines the friction in the lines and other passages through which it must flow and in this way affects the pressure required to get the oil to the burners in proper quantity for atomization. The viscosity of the oil therefore has much to do with the size of the lines, pumps, heaters and the capacity of the burners.

Capacity Related to Viscosity

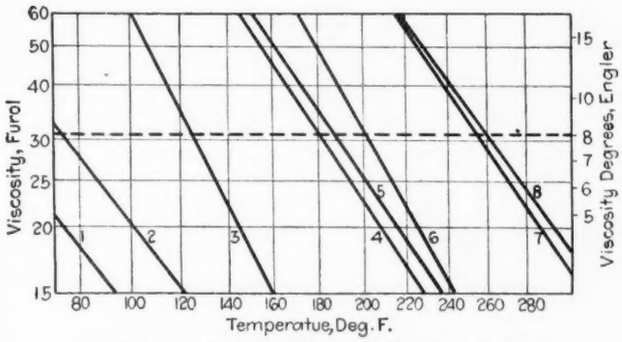
The capacity of a burner of any given design varies with the temperature and the viscosity of the oil. There is a definite temperature for any given burner at which a certain fuel oil will give best results. Increasing the temperature beyond this point results in a decreased capacity of the burner. The question now is, how can the correct viscosity and temperature be determined?

Fuel oils vary widely in their viscosity characteristics, both as to the degrees of slope of the viscosity curve and as to the actual viscosity at various temperatures. The diagram shows temperature-viscosity curves of various grades of fuel oil, the readings on the Furol viscosimeter being shown on the left, with Engler degrees on the right.

The usual practice heretofore has been to purchase fuel oil on the basis of gravity and regulate the efficiency of combustion by the appearance of the flame, checking it with a CO_2 recorder. Since the capacity of a burner varies with the viscosity of the oil, the oil must be of the right viscosity when it reaches the burners, in order to obtain maximum capacity. The only way in which the viscosity can be controlled is through regulation of temperature. If this is done by adopting a certain temperature for each gravity oil, a considerable error can easily be introduced. The oils represented by curves 7 and 8 require practically the same temperature for atomization, oil 7 requiring about 5 deg. F. less temperature than 8; oil 7 has a gravity of 10 Baumé, whereas oil 8 has a gravity of 13.7 Baumé; oil 4, with a gravity of 17.1 Baumé, requires a temperature 50 deg. F. higher than oil 2 with a gravity of 19.8 Baumé—all of which shows the difficulty of attempting to regulate atomization by temperatures based on gravity alone.

The experience of the oil-burner manufacturers has also shown them that the efficiency of a burner is closely related to the viscosity of the oil in use. One of the leading manufacturers of burners for boilers and industrial furnaces recommends that the viscosity of the oil reaching the atomizer be held at about 8 degrees Engler, equivalent to 30.5 seconds Furol, as the burner is designed to handle fuel at that viscosity most efficiently. If the viscosity of the oil is higher than this figure, the efficiency of atomization is decreased and perfect combustion is more difficult to secure. Viscosity has a direct bearing on the ease with which the oil can be broken up and on the size of the particles after atomization. On the other hand, if the viscosities are reduced below this figure, although atomization may be improved, the capacity of the burner is reduced.

The dotted horizontal line drawn through 8 deg. Engler shows to what temperatures the various grades of fuel oil must be heated in order to obtain proper viscosity at the atomizer. Two of the oils, 1 and 2,



TYPICAL TEMPERATURE-VISCOSITY CURVES

have a viscosity below the recommendation made above, at all temperatures at which the oil would be likely to be supplied at the atomizers. Such oils would require no preheating whatever. All the other oils shown must be heated to the temperatures indicated to secure proper results.

Another type of burner might require a different standard of viscosity, so that it would appear that each burner manufacturer should advise the proper viscosity at which the oil should be supplied to the burner for best efficiency. The fireman can then control the temperature of the various oils he is likely to get to secure this viscosity.

Obviously, in order to secure maximum efficiency it is desirable to maintain the oil at the correct viscosity by carefully regulating the temperature. The best way to do this is to obtain from the refiner a temperature-viscosity curve of the oil purchased, and from this curve determine the temperature necessary to secure the desired viscosity. Furthermore, as the viscosity of each shipment of fuel oil will probably be different from the

preceding, a viscosity reading should be made when the oil is put into the tanks. In fact, it is very desirable to take viscosity readings of oil in storage at frequent intervals on account of the tendency of some oils to change in character when stored under variable temperature. Certain Mexican oils have a peculiar physical characteristic in that the viscosity does not change instantly with the temperature.

A sample of Mexican oil tested at 60 deg. F. and stored for six days at 32 deg. F. and again tested at 60 deg. F., was found to have increased one-fifth in viscosity. Another sample heated to 150 deg. F. for 49 hours, was found to have only one-half the original viscosity when again tested at 60 deg. F.

Viscosity May Change During Storage

A third sample was stored at 32 deg. F. for 120 days, and at the end of this time the viscosity at 60 deg. F. had risen to 2¼ times the original value. The same sample was then heated to 100 deg. F. for two hours, after which the viscosity at 60 deg. F. was found to have returned to its normal value. Evidently, in determining the proper temperature for securing the most efficient viscosity of oils of this character, it would be desirable to take the viscosity reading after the oil had been in storage at the temperature under which it is to be removed for use.

Another point to be watched in connection with viscosity is the flash point. The flash point of the oil 8 is only 140 deg. F. This means that it must be maintained at a comparatively low temperature, certainly not over 125 deg. F., in the storage tanks to prevent vaporization and possibility of fire. At this temperature the viscosity is so high that the oil could not be handled properly through the lines, and the oil cannot be considered as suitable for this purpose. Proper atomization of this oil requires a temperature of 260 deg. F. The only way to burn such an oil is to heat it under pressure, thereby preventing vaporization when heated above its flash point. Oil 7, on the other hand, having a flash point of 374 deg., can easily be stored at a higher temperature and does not have to be heated under pressure to lower its viscosity to that required by the burners.

Flash Point Sometimes A Limiting Factor

If the fuel available is a "topped crude"—that is, a crude oil from which a portion of the gasoline content has been removed, thereby raising its flash point—almost any degree of viscosity can be handled by storing the oil at temperatures sufficiently high to permit its flowing to the pumps properly, and subsequently heating under pressure, if desired, to the required viscosity. On the other hand, if only straight crudes are available, the burners have to be designed to operate efficiently on an oil of high viscosity at a low temperature.

Steam and air atomizing burners, because of the expansion of the atomizing medium, can give satisfactory atomization of oils at comparatively high viscosities and correspondingly lower temperatures. The mechanical atomizer, on the other hand, because there is no expanding medium, requires an oil of lower viscosity. This means heating the oil to a higher temperature or purchasing lighter grades.

The same general principles apply also to the Diesel and semi-Diesel engines with respect to the atomization of the fuel. Efficiency of combustion of any liquid fuel depends upon the completeness of gasification, whether it is burned in a gasoline engine, Diesel engine or under a boiler. Gasification is influenced in turn by the fineness of atomization. In the automobile engine atomization and vaporization of the fuel is comparatively simple, although even here the viscosity of the fuel plays a much larger part than most people imagine. In the Diesel engine atomization is assisted by the expansion of the air injecting the fuel into the cylinders, but in the solid-injection engine where the fuel is injected into the cylinder by means of pumps, proper atomization is more difficult to obtain. Consequently, it is important that the viscosity of the fuel at the time of delivery to the atomizer be held within definite limits.

Most oil engines are built to handle a wide range of fuels. One reason why some of them do not always perform equally efficiently on oils of identical gravities is because the oils do not have the same viscosities. Some experiments made on a Diesel engine by Harold Moore showed conclusively that the efficiency of an oil engine can be greatly improved by decreasing the viscosity of the fuel oil delivered to the atomizers.

Each type of oil engine undoubtedly has a definite range of viscosities within the limits of which it will give the most satisfactory results. As a point of service to their customers and for the good of the general public, every oil-engine manufacturer should determine the most suitable viscosities for his engines and advise the customer accordingly. Working from the temperature-viscosity curves of the various fuels with which he may be supplied, the engineer can then adjust the heaters so as to get the proper viscosity of each fuel.

Effect of Viscosity on Heater Capacity

The viscosity of the fuel oil also has a great influence on the capacity, type and efficiency of the heater. If the heater consists of a coil of pipe immersed in the oil, the oil immediately adjacent to the pipe will be heated, but that part of the oil farther away will receive heat very slowly. In order to heat a large quantity of oil, there must be a rapid circulation past the heating surface. This is difficult to obtain when high-viscosity oils are used and, as a result, there is local heating with excessive evaporization and carbonization. With a thin oil rapid circulation takes place and these troubles are eliminated.

When the oil is forced through pipes surrounded by a bath of steam, better results are often obtained, because no dependence is placed in convection and the viscosity will have no effect on the quantity passed through the heater other than to require a higher pressure at the pumps for high-viscosity oils. To secure proper heating of a high-viscosity oil, it must remain in the heater longer with a consequent reduction in heater capacity.

It is believed that if all engineers interested in the efficient handling of fuel oil were to give closer attention to this physical characteristic of viscosity, a great deal could be done to decrease the annual waste of fuel oil, and at the same time improve the conditions of combustion and eliminate many of the troubles caused by incomplete combustion.

When grinding the collector rings of an alternating-current generator such as a turbo-alternator with end shields close to the shaft, a felt collar can be used to advantage to prevent dust going in. Bearings should be protected in long grinding jobs by a felt or rag collar around shaft. Oil caps, etc., should be covered with canvas or heavy paper.

EDITORIALS

F. R. LOW, EDITOR

Why Discriminate Against Engineering Student?

THE educational laws of New York State provide five scholarships to each county annually for each assembly district therein. Such scholarships entitle the holder one hundred dollars for each year that he is in attendance upon an approved college in the state during a period of four years. The selections are made according to the relative standings of the candidates provided the student has completed within six years of enrolment an approved four-year high-school course in a registered secondary school of the state and has passed the prescribed Regents examination with an average standing of not less than seventy-five per cent and a minimum passing mark of sixty-five for any subject. There are exceptions to the requirements regarding attending secondary schools if the student's standing attained in examinations indicates exceptional scholarship.

In Sec. 77 of this law it is stated that, "A person entitled to such scholarships shall not be restricted as to choice of the college which he desires to attend, or the course of study that he proposes to pursue; provided that no such scholarship shall include profession instruction in theology, or in any profession, admission to the practice of which shall require a license from the state or in any graduate courses following the receiving of a bachelor's degree; and provided further, that the college selected is in the state of New York and authorized under the laws of the state."

August first of this year the New York State law, requiring engineers to have license in order to practice professional engineering became effective. According to the clause in the educational law quoted above, the student wishing to take an engineering course is ineligible to receive a state scholarship. Students who have won scholarships this year and have expressed intention of pursuing engineering courses have been notified by the State Department of Education that their applications for university scholarships are not approved and if they desire to follow engineering they are requested to file their formal declinations of the scholarships recently offered them.

How then, can students be encouraged to take university courses in engineering if the state will reward them for not following such professions? Those familiar with the remuneration received by engineers for their services know this is not very attractive. Figures compiled by Walter St. John, of the United States Bureau of Education, show a decrease of 5,697 students enrolled in 129 technical schools of the United States for the year 1922-1923 as compared with the previous school year, for courses in the five major branches of engineering, electrical, mechanical, civil, mining and metallurgical and chemical. The totals for the two consecutive years were 56,176 and 50,479, respectively, or a decrease of over ten per cent. In chemical engineering the decrease was the highest, namely, 9 per cent. It is easy to understand the reason for this decrease in the engineering student enrollment in this country if such conditions as exist in New York State obtain in other states.

The various engineering societies have recently been taking a more active part in public affairs with the object of rendering greater service to the community. This is an excellent sentiment and is probably what is justly the sphere of the engineer in those things that he is qualified to deal with on account of his training. However, it would not be amiss for him to consider what the community is doing for him and take proper steps to prevent engineering students being discriminated against by educational laws.

Possible Improvements in Prime Mover Governing

ALTHOUGH innovations have been introduced in the governing of small or medium-sized units, large steam-turbine governors and valve gears have changed little in the last ten or fifteen years, in contrast to changes in other elements of the large steam turbine.

There has been notable improvement in mechanical construction, accessibility, etc., and some of the early valve gears soon gave way to better proportioned or more economical designs. However, the hydraulic type has proved so satisfactory for numerous applications that little need of improvement has been felt.

When the breaker on a direct-current unit is opened by a sudden overload, it often happens that the voltage rises only two or three per cent above normal. Such operation is practically perfect. For a succession of rapid, wide load variations, however, the governing device is easily at a disadvantage. Fortunately, such conditions are seldom encountered in ordinary practice. Turbines driving alternating-current generators are liable to much greater inconvenience from sudden overloads, when there is a heavy time-element adjustment on the generator tripping mechanism.

When several plants operate in parallel to supply a widely varying load, such as that of electric furnaces or large rolling mills, the maintaining of a fairly constant frequency may involve considerable load dispatching and adjusting, especially if the plant efficiency of one station justifies a base type load. It may be bothersome for the control-room operator to vary the speed setting of five or six prime movers at one time, in order to change the load in one station, and maintain suitable frequency. In looking at actual working conditions, there are indications that improvements in several respects are possible.

In the first place, one governor may control several prime movers in parallel to better advantage in some ways than by the time-honored custom of using individual governors. This only requires that the hydraulic gear or other auxiliary device controlled by the governor must be connected to the valve element of each unit and be powerful enough to follow the governor movements closely. Each prime mover then will auto-

matically take its required proportion of steam, proper exhaust conditions being assumed. The necessity of adjusting an exactly equal speed regulation for each of the individual governors, in order to obtain proper division of load variations, is thus avoided. This is only an illustration of which better applications are undoubtedly at hand. Conditions other than parallel operation will also require to be taken care of.

In the second place, the whole plant frequency, or at least that of all the prime movers controlled by one governor, may be adjusted in the control room by means of one synchronizing spring and hence by one operation. This would greatly reduce the work and care usually required in changing load with individual governors.

Thirdly, the effect of a surge in electrical load may be readily offset by means of an auxiliary governor control operated from the electrical end. Governors now can operate only on changes of speed. With electrical compensation valve-gear operation may to some extent anticipate changes in speed. Stability of operation would limit the amount of such compensation. Under normal conditions it would not be required.

An early turbine valve gear containing electrical features did not prove an unqualified success. It was soon abandoned for a pure hydraulic type. The impression produced by this electrical control, which functioned so as to operate the valve element in relation to the centrifugal governor movement, seems to have dispelled all thoughts of ever returning to electrical means of governing. Meanwhile, the hydraulic turbine in one instance, has combined electrical features with its governing mechanism, and the result has been a practical success. While in small or medium-sized steam turbines governing leaves little to be desired, in the case of a large power system, where a constant frequency must be maintained and base-load stations supplied, a judicious electrical control would make system operation possible from one central point, with abnormal load conditions automatically handled to better advantage than at the present time.

Oil Engines of Large Powers

IN 1910 the German Government designed a battleship to be equipped with Diesel drive. Two 12,000-hp. two-cycle, double-acting Diesels were to be direct-connected to the center propeller while two outside screws were to be steam driven and used only when maximum speed was desired.

The first of these 12,000-hp. Diesels was destroyed by a fire in 1912 but the operation on the test floor was so satisfactory that the construction of the second engine was continued. Unfortunately the Allied Commission could not comprehend the engineering benefits that would result from placing this unit into service in some power plant, and it was ordered destroyed.

The breaking up of this engine has not prevented engineers from feeling that large Diesels are possible, and actual construction of such units only await the arrival of purchasers having faith in the idea. Granted that Diesel engines of from 6,000 to 12,000-hp. are possible the question naturally arises as to their effect on the relatively large steam stations. With, say, five units of 6,000 hp. each, installed in plants located at the center of the demand, the transmission losses occasioned by the concentration of steam generating equipment in a single plant far removed from the center of the load would be eliminated. Of course, such interconnection as is desirable as a safety measure and for considerations of load factor must not be overlooked.

The chief objection likely to be raised is one of expense but if the costs of smaller units may be used as a criterion there is reason to feel that Diesel equipped stations of large capacity would be comparable to steam plants, and perhaps cost less. Operating costs with the Diesel are lower than for a steam plant of like size and, if the actual investment proved to be lower or no more than the steam plant, the cost per generated unit would be well under present-day central-station practice.

Ten years ago when coal was procurable at two dollars a ton, in the bin, the steam plant was without argument the proper type of plant. True the increase in coal costs has prompted designers to build plants with higher thermal efficiencies than formerly but each reduction in the pounds of coal per kilowatt-hour is countered by a boost in the price of coal. At present coal costs are such as to cause many to seriously consider oil engine plants.

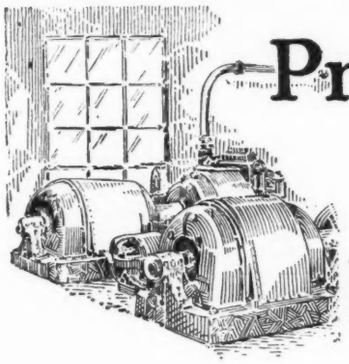
Isn't it So?

IF SOME highly intelligent being with a cynical sense of humor should descend to earth from Mars, or some other planet, he would not need to read the funny papers, or go to the movies to find ample amusement. A little trip through the workaday world would be quite enough. One of his chief sources of amusement would be the amazing inconsistency of the human species, even of that more intelligent portion composed of business and professional men. He would see mankind engaged in developing science wonderfully suited for human advancement, only to use the results of this science in wars of destruction. He would see men looking upon insurance as a satisfactory substitute for fire and accident prevention. He would see people spending hard-earned money for utterly useless things, on the efficient manufacture of which skilled minds were concentrating their attention. He would see supposedly sane and normal citizens seeking new ways to kill time, of which they have only 70 or 80 years at the best, with thousands of worth-while things waiting to be done.

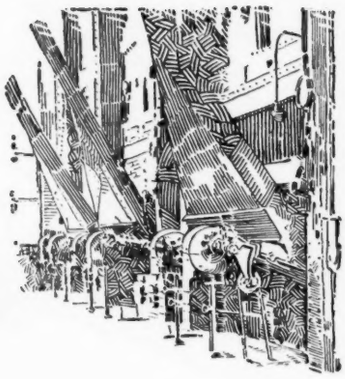
He would observe on the one hand a set of men laboring blindly without understanding the first principles of their task, or having even the roughest of data as to actual accomplishment, and on the other hand another group so wrapped up in blissful contemplation of formulas, card indexes and voluminous records as to forget to make any practical use of them.

But of all the things he would see, nothing would amuse him more than the sight of numerous business men keeping accurate records of every penny spent for office boys and postage stamps, while at the same time allowing thousands of dollars worth of coal, stacked up in the yard, to be burned, without asking for any information as to how effectively it is used—even more, refusing even to supply the only means of getting that information.

As this issue goes to press fragmentary details are coming to light concerning the suffering and hardships consequent upon the great catastrophe in Japan. President Coolidge has appealed to the American people to help, and in response to this appeal it is hoped engineers will do their share.

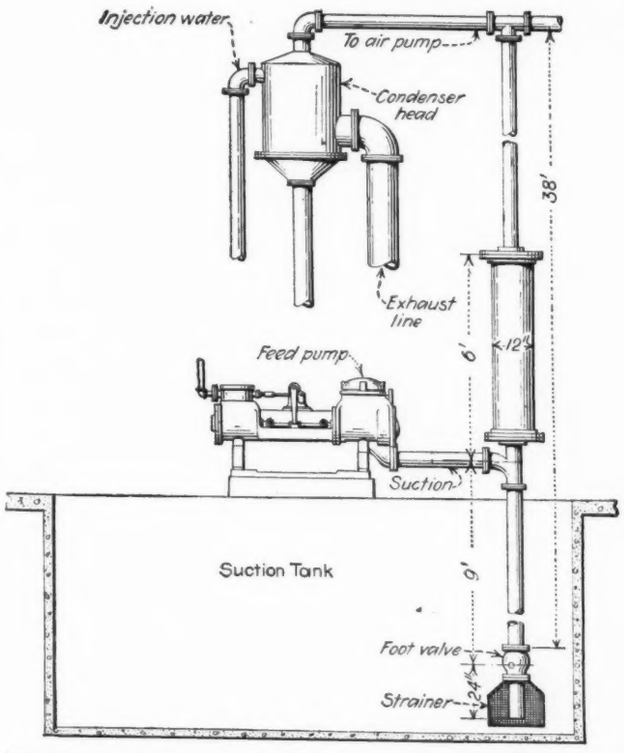


Practical Ideas *from* Practical Men



Pumping Hot Water with the Aid of a Vacuum

Most engineers are familiar with the trouble encountered when attempting to pump water at a temperature of 150 deg. or above, from a tank situated below the level of the pump. There are many plants, however, where it is not possible to locate the clean drip tank at a level above the feed-pump suction. With the tank below the pump it is necessary to keep the temperature of the water below a certain point so that the feed pump will operate smoothly. In order to do this, some



VERTICAL SUCTION PIPE IS EXTENDED AND CONNECTED TO AIR-PUMP SUCTION

means of cooling the water before it reaches the pump is often resorted to or hot water that should be led to the tank is piped to the sewer.

In the illustration is shown the method we have in use in our plant to overcome this difficulty. The lowest level of the water in the drip tanks is 11 ft. below the feed-pump suction, and we have no trouble in pumping water at 180 deg. F. or above. From the pump the water is passed through a closed heater and raised to approximately 210 deg. before entering the boiler.

Referring to the illustration, it will be seen that the vertical suction pipe is extended to a distance of 38 ft. above the foot valve and connected to the air-pump suction from the condenser head. The pipe is enlarged above the pump to act as a head tank and to prevent the possibility of breaking the column of water above the pump. It will be readily seen that the vacuum maintained by the vacuum pump will support a column of water in the suction pipe at a sufficient height to give a head on the pump suction at all times.

When a condensing equipment is not used, the same results can be obtained by extending the suction pipe as shown and connecting a small vacuum pump to the upper end of the pipe.

H. W. GEARE.

New York City.

Preventing Copper Floats from Collapsing

There is an old saying that an ounce of prevention is worth a pound of cure, which appears to me to be particularly applicable to copper ball floats, because they frequently require straightening out and much time is lost getting them out of the traps and in place again.

Sometimes copper floats are indented by striking parts of the trap, inside projections, etc., and also in some cases by slugs of water coming at high velocity from the pipe, such as when water hammer occurs, but most traps are so made that incoming water cannot strike directly on the copper float.

Of course when a trap is under pressure, even if only a few pounds, it takes but little additional pressure, at any point, to cause an indentation, therefore, if we can neutralize the pressure inside and outside the float, the whole resistance of the float is available against the local indenting force. Now such an internal pressure could be obtained by having a small quantity of water inside the float as it would vaporize into steam at the same temperature and pressure as the steam in the trap, but the water would weigh considerable and so decrease the buoyancy of the float. Much better still would be a small quantity of a more volatile fluid such as gasoline, denatured alcohol, ether, etc. This could be easily introduced by any engineer through a $\frac{1}{16}$-in. hole drilled in the float, and then the hole sealed up by soldering.

Compressed air could be introduced through a small check valve, on the end of the inlet pipe, within the float, and when the desired pressure was attained the supply pipe could be disconnected and the outer end

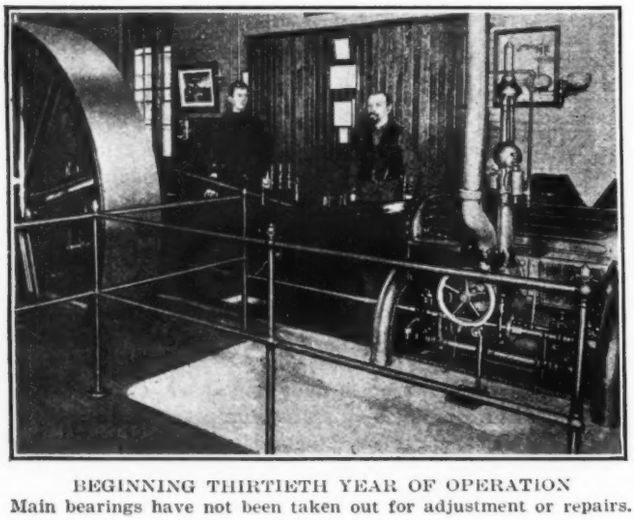
sealed by soldering, then the pressure of the air would increase with the temperature. It is my opinion, however, that introducing a small quantity of one of the liquids mentioned is the simplest and best method and I hope the day will come when all float manufacturers will send out floats so treated and fitted with small badge plates stating what liquid has been used, the quantity, and at what pressure and temperature the inner and outer pressures will neutralize also the buoyancy at complete submergence. F. W. SALMON.

Richmond, Va.

A Veteran Steam Engine

One unit in my plant consists of a 14x36 Putnam engine. For two years the speed was 50 r.p.m. A generator was then added to the plant, and the speed of the engine was increased to 75 r.p.m., and it was so run for 18 years. As more power was subsequently wanted, the speed was further increased to 100.

At first the steam pressure was 60 lb., but it has since been increased to 90. For 20 years the engine was belted to a jackshaft, from which power was taken for various purposes in the usual way, but then it was decided to electrify the shop. The jackshaft was discarded, and an 85-kw. generator was installed instead and power used for about forty motors. For 18 years the expense for repairs on this engine was less than five dollars. For 28 years and 6 months only one kind of cylinder oil was used on the engine, to the exclusion of all others. The 20-in. main belt lasted 28 years and 6 months, but was then worn out and was replaced by a new leather one.



BEGINNING THIRTIETH YEAR OF OPERATION
Main bearings have not been taken out for adjustment or repairs.

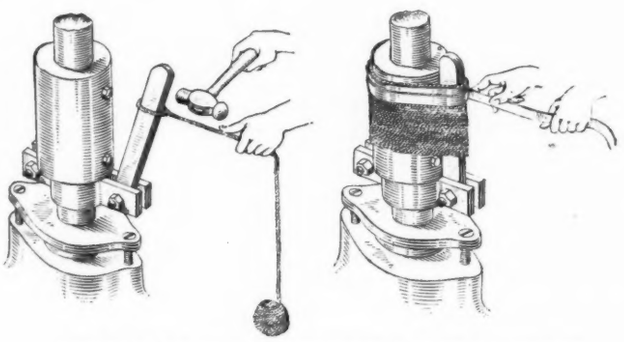
During this long term of service only one kind of packing was used on the piston rod. After 18 years of service a cut was taken on the piston rod, but it had been worn so little that $\frac{1}{64}$ in. removed all imperfections. The guides are not worn enough to be perceptible. The crankpin boxes, also the wristpin boxes, are worn very little and have never been replaced. The main and outboard bearings give perfect satisfaction and have never been taken out for adjustment or repairs.

This engine is now ready to begin the thirtieth year of service and apparently is good for many years to come. W. H. WAKEMAN.

New Haven, Conn.

Temporary Repair to Oil-Pump Drive While Running

The oiling system on our unaflow engine consists of an overhead tank from which the oil flows by gravity to all the bearings and from there drains into a filter in the basement of the engine room. From the filter it is again pumped up into the overhead tank by a gear pump. The pump is driven by a vertical shaft which in turn is driven from the governor shaft by a pair of miter gears.



TEMPORARY CLAMP SECURES LOOSE COUPLING

One morning when I arrived at the plant, the oiler was carrying oil from the filter up two flights of stairs to the overhead tank. The day assistant engineer informed me that one of the bolts in the coupling connecting the pump with the vertical shaft had broken about two o'clock, and in order to keep the engine running until I arrived, the oiler had been kept busy carrying oil from the filter to the overhead tank.

I immediately ordered one of the pipefitters to carry the oil so the oiler could follow his regular duties. Then I examined the pump and found that the coupling was turning with the shaft, but the pump was idle. I ordered the machinist to make a clamp to fit the pump shaft, with enough opening between the halves of the clamp for a lever, as shown in the figure. The clamp was fastened to the pump shaft below the coupling, and a piece of chalk line was tied to the lever. The lever arm was then knocked in against coupling and the bolts caught the lever and started it rotating. The string was then wound around the coupling and lever. To prevent the string from unwinding, friction tape was wrapped over it.

The engine turns 150 r.p.m., so everything had to be in readiness and done quickly; by 9 a.m. the pump was running. It ran nicely until the following Sunday, when the clamp was removed and two new bolts were put in the coupling and the firm was saved the expense of a shutdown. A. A. FETTE.

New Iberia, La.

Water in a Semi-Diesel

The introduction of water into a semi-Diesel engine cylinder, during the scavenging part of the stroke serves to lower the temperature of the hot piston head and cylinder walls. The air, on entering the cylinder, does not heat up so much. A greater weight of air will then be trapped in the cylinder and, since the power output depends upon the weight of air present to be combined with the fuel, the water enables the engine to burn more fuel and develop more power.

Comments from Readers

Planimeter Used for Averaging Charts

Referring to an article in the issue of July 31, I would like to offer a few suggestions that might simplify the work of P. B. Jameson, who contributed it, and also the work of chart keepers who are compelled to use either the averaging method or several special planimeters. I understand that a special planimeter is best for the work it is designed for, but it is not versatile.

We have four types of charts which are averaged every day, and if they were to be computed on an adding machine or manually, the work would be quite expensive. With an ordinary Amsler planimeter of the type used by civil engineers, the work is shortened by at least nine-tenths. The instrument may be used on circular or rectangular charts with either equally or unequally divided spaces. The procedure is simple and requires nothing but the use of plotting paper, an accurate scale and simple arithmetic or a slide rule.

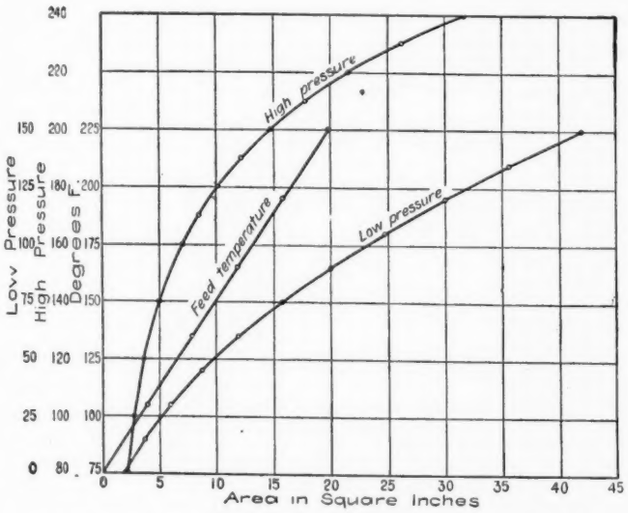
Take any chart and measure the distance from the center to each of the graduations, putting down the radius in one column and the reading of temperature or whatever the scale is, in the next. When the whole radius of the chart has been so covered, compute the area of the circles corresponding to the radii. It is plain that it does not matter, with this method, whether the spaces between each division are equal or not, as it does in the method of Mr. Jameson. His method is simple for equal divisions, but would require a complicated formula for any other condition. Moreover, there is a duplication of effort when the results one day are the same as those of some other. With the plotting paper the results are computed once and for all; thereafter it is simply a matter of finding the point on the curve that satisfies the conditions and taking the figure down. With a rectangular chart the procedure is slightly different. Here, the length of the chart multiplied by the height of the divisions is set opposite to the reading. It is really much easier than the circular chart.

When the figures for all the charts to be metered are put in order as suggested, the actual plotting may be done. Since it is the area that we work with to establish the result, it should be laid out as abscissas along the bottom. Now working from the tables made, plot against the area the temperatures, pressures, etc., as ordinates. Care should be taken here to arrange the spaces so that the curve may be read to the accuracy of the chart. For instance, if it is possible to read the curve on the chart itself to two degrees, then the curve on the plotted sheet should be so sloped that the same may be done there.

The figures from which the curves are plotted should be put in some more permanent form, if possible, on the front of the plotting paper or on the back.

The operation of getting the average of any chart consists of choosing a starting point, taking the planimeter reading, moving the tracer over the curve in a clockwise direction to the starting point and again reading. Subtracting the first reading from the second gives the area in square inches. This area is found on the bottom of the chart and the vertical followed to the curve, reading off on the left-hand side (or right if so plotted) the resulting average.

An effort should be made to keep the chart as neat as possible. Where the lines are straight, it is a simple matter, but where they are curved a French or flexible curve should be used. A method that the writer has always found to give a neat appearance and



AVERAGE CHART READING OBTAINED FROM AREA

individuality to the different curves is to scribe a very fine circle around each plotted point, or if they are too close to each other skip one or two, and color this circle with crayon or ink. If the circle is made as small as possible and the curve drawn just up to it and not through, the draftsman will feel rewarded for his extra care by the result. Use india ink or some similar product throughout, and when completed, if the chart is on thin paper, paste it on heavy cardboard. If it is to be used where there is grease or dirt, cover it with a transparent cover, and it may still be used just as efficiently.

H. A. POOLE.

Wappingers Falls, N. Y.

Permissible Expansion with U Bends

The article "Writing Pipe Specifications," by Herbert E. Collins in *Power*, Aug. 21, 1923, page 288, included a chart, Fig. 3, covering expansion taken care of by bends. The values there given have been demonstrated to be at least partially incorrect.

Reference should be made to an article in the *Mechanical Engineer* of March, 1923, reporting on a paper presented before the American Society of Mechanical Engineers, on this subject in which it was demon-

strated, by experiment, that, taking a 90-deg. bend as unity, instead of the ratios of 1, 2, 4 and 5, the values used in this table, the true relations are 1, 4.4, 13.2 and 32.9, for a 90-deg. bend, a U bend, an expansion bend, and a double offset U bend, respectively. The values given in the table for the double offset U bend are approximately correct, from which it will be seen that the values given for the smaller bends are far too great and that the use of this table is apt to lead to very serious results.

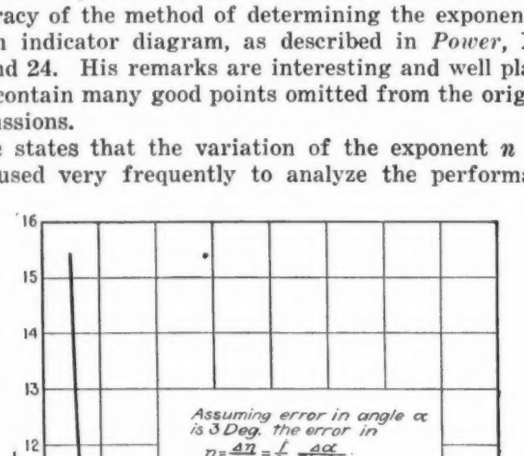
H. A. WARD.

Cornell University.

Analyzing Indicator Diagrams

In *Power*, June 5, Mr. Wolf took issue as to the accuracy of the method of determining the exponents n of an indicator diagram, as described in *Power*, May 10 and 24. His remarks are interesting and well placed and contain many good points omitted from the original discussions.

He states that the variation of the exponent n was not used very frequently to analyze the performance



ERROR IN n

of the engine, for two reasons: First, the results obtained were dependent upon the correctness of the indicator diagrams; second, it took too much time to determine the exponent n by calculations. It is a pleasure to note that in Mr. Wolf's opinion the second reason is now eliminated.

The inexactness of the usual indicator diagram and the many sources of error are well known to the writer and it would be ridiculous to claim that the accuracy of the results obtained in determining the exponent n, can be greater than that of the diagrams used. In basing flywheel calculations on the indicator diagram, water-jacket calculations on the heat transmission data, connecting-rod calculations on the strength of materials, the designer depends on the correctness of figures which have but a limited accuracy.

The indicator diagrams shown were not used for the purpose of a research investigation; they are merely examples to show in an effective way how to read the n curves derived from the various indicator diagrams and if they helped this end, they fulfilled their duty.

Mr. Wolf also states, quite correctly, that the inaccuracy of the analysis is increased by the inexactness of tangents drawn to various points of the indicator curve, and wants a statement as to the limits of accuracy that may be expected. Differential calculus applied to the determination of error gives us the answer.

Assuming that an error dx is made in drawing the tangent, what is the relative error in n? This depends on the angle between the tangent and the horizontal axis. If it is assumed that the possible error in drawing tangents is 3 deg. which hardly can be exceeded, the curve in the illustration shows the possible errors of n in per cent.

It can be seen, that the error is smallest when the tangent is 45 deg., the error being about 2.5 per cent. When the tangent is 80 deg. or 5 deg., the possible error increases to about 7.5 and 15.5 per cent respectively. The remedy, however, is simple: Draw that part of the curve in which you are interested, to such a scale that the curve lays approximately 45 deg. to the horizontal axis. Then the possible error never will exceed 3 per cent. In most cases, it is the middle part of the expansion stroke in which we are most interested. For this period, the indicator diagram can be used without scaling. Here the accuracy of the graphical method compares very favorably with the analytical. The method, with a certain modification, can be applied to the so-called offset diagrams too, which facilitates the study of the process at dead center.

It is hard even with the free eye to draw a tangent to a curve, differing more than 3 deg. from the true tangent. The mirror rule helps distinctly in this respect. It is a good practice to draw two lines to each point, reversing the position of the mirror rule by 180 deg. and draw the tangent between these two lines.

P. H. SCHWEITZER, M.E.

Pontiac, Mich.

Lubricants and How To Test Them

I read with great interest the editorial in the June 19 issue, "Turning the Spot-Light on Lubrication," because it is a straight-from-the-shoulder statement of the situation and the point is very forcibly made that what is known concerning lubricants and lubrication is insignificant as compared with what ought to be known.

Lubricants minimize the friction existing between two surfaces when one slides or rolls over the other. The surfaces set up friction themselves, and our engines and machinery have to overcome two classes of friction—that arising from the metal surfaces sliding over one another and the internal friction of the lubricant. The first we term solid friction, the second fluid friction, and it is the aim, or should be, of all engineers to reduce the first to nil and the second to a minimum.

The nearest approach to this ideal is obtained by the

use of an oil bath containing a fairly fluid lubricant, and with, of course, accurately made bearings. The ideal condition is one where the sliding surfaces are completely separated by a film of lubricant. Like other ideals, it is seldom attained, so that for all practical purposes we have compound friction—that due to the action of surfaces partly separated by a fluid, in which there is solid friction where the bare surfaces touch one another, and fluid friction where the lubricant intervenes.

In most of the classes of bearings the lubrication is far from perfect, but is generally adequate for the purposes in view. The question of the reduction of friction, with its lost work, is often a matter of expediency, and it may be less costly to go on using bearings that are not perfect than go to the expense of paying for better ones. A true oil-film bearing is not only somewhat costly in the first instance, but requires the expenditure of a good deal of skilled care on its satisfactory maintenance. Where the shaft loads are great or thrust loads high and the speed of revolution also high, something should be done to carry the pressures without undue loss of work against friction.

In selecting oils for low speeds and high pressure, viscosity must be the first consideration, and next to that, "oiliness." If the viscosity is high enough, mineral oil may be as good as, or even better than, any other, or a mixture may be preferable to either. Mineral oils are excellent for bearings subjected to comparatively light loads and running at moderate speeds. In general practice the viscosity should increase as the speed of rotation diminishes; this applies particularly to mineral oils. As the loads increase, wear and overheating may result unless animal or vegetable oils are added. The necessity of using expensive "fixed" oils instead of the cheaper mineral oils is sometimes due to imperfect lubricating devices. The specific gravity of mineral oils usually varies from about 0.860 to 0.940, and the flash points from 300 deg. to 600 deg. F. The oils obtained from petroleum have a much wider range of viscosity than the fixed (animal or vegetable) oils. The thinnest are more fluid than sperm oil and the thickest more viscous than castor oil.

The shale lubricating oils are of low viscosity. "Fixed" oils are so named because they do not become volatile without decomposition. They are obtained from the seeds or fruits of plants or the tissues of animals. The specific gravity of fixed oils varies from about 0.879 to 0.968 at 60 deg. F. Sperm oil has the lowest viscosity and castor oil the highest.

The quality and properties of some lubricating oils can be determined approximately without the use of special testing apparatus. To determine the presence of solid impurities in the oil, kerosene is added to half a tumbler of oil until the whole becomes quite thin. The mixture is then passed through filter paper or ordinary white blotting paper, and after all the oil has passed through, the paper is washed with kerosene. The residue on the paper, if any, will show if the oil contained any solid impurities.

Impurities may also be roughly detected by smearing a piece of writing paper with oil and holding it against the light. If the oil is free from solid impurities the blot will be equally transparent throughout, otherwise the solid particles will show. The oil should not resinify. To test it in this respect, pour it into a shallow enamel or earthenware bowl, and leave in a warm place for a few days. There should not be the slightest formation of crust at the end of the testing period.

Acids are injurious impurities in lubricants, as they attack the parts lubricated. To test for acids, copper ash or copper oxide is added to the oil in a glass vessel; acid-free oil retains its original color, while if it contains acid, it becomes bluish or greenish. Another simple test is to drop the oil on a piece of copper or brass sheet and leave it for, say, several days; if the oil contains acid, there will be a greenish color spot on the metal. Cylinder oil may be tested by heating it and noting its color. A good cylinder oil will not change color to any noticeable degree when heated to 475 deg. F. or to a temperature higher than that existing in the engine cylinder. Low-grade oils invariably darken when heated to this temperature.

Another test for cylinder oil is the flash test. The oil is placed in an evaporating tray or dish and heated with a bunsen burner. A thermometer is suspended in the oil so that it will not touch the side or bottom of the vessel. After the temperature has reached about 150 deg. F., a small flame should be brought near the surface of the oil. The flame is brought near the surface every two-degree-rise in temperature. When the oil reaches a certain temperature, a snappy blue flame will shoot across the surface when the testing flame is brought near. When this appears, the temperature of oil should be immediately recorded, as this is the flash point. In carrying out this process, the temperature of the oil should not be increased over 8 deg. F. a minute. Ordinary lubricating oil should have a flash point of about 350 deg. F. Oil for cylinder lubrication should not have a flash point below 500 deg. F.

The information obtained by these simple tests is quite valuable, especially from an economic working point of view, and it is to the national interest that the maximum useful results should be obtained in dealing with lubricating oils.

E. ANDREWS.

Manchester, England.

Will Change from Vertical to Horizontal Baffling Increase Furnace Temperature?

Referring to the article by F. Williams in the July 17 issue, in which he shows a cross-section of his furnace and also the proposed change in the boiler baffling, I would not advise him to change from vertical to horizontal baffles. It has been my experience that a boiler of this size and type is more economical with vertical baffles.

I do not think that the location of the baffling alone is responsible for the low temperature, as there are other factors which may bring about this condition. Common causes of low temperature are too much draft with a thin fire and the placing of the grates too close to the tubes. A vertical baffled boiler of the size given should be more than 48 in. above the grates; 72 in. would be better.

The horizontal baffles would no doubt raise the furnace temperature some, but not necessarily the furnace efficiency; under certain conditions the efficiency might be lowered.

L. B. SHIELDS.

Chicago, Ill.

When burning small-sized anthracite on a hand-fired grate disturb the fuel bed as little as possible with the firing tools. Keep the fire an even thickness, level occasionally if necessary by using a light bar made of 1 in. pipe.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Electric Welding of Boiler Patches

We have a return-tubular boiler used as a hot-water heater with relief valves set at 65 lb. per sq.in. The boiler has a halfmoon-shaped patch on the under side of the shell just back of the first girth seam. The patch has been leaking, and it has been proposed to cut out the old patch and replace it with a piece of boiler iron electrically welded to the main sheet and joined to the forward sheet in the shell by rivets. Would such a repair be regarded as good practice?

H. M. K.

Boiler patches of this kind are not considered to be reliable, as they have shown signs of failure after a comparatively short period of use and when the welding has been performed with greatest care.

Relative Advantages of Injector and Feed Pump

What are the relative advantages of using an injector or a pump for feeding a boiler? J. F. G.

An injector, considered as a pump, has an efficiency much below that of the direct-acting steam pump, but considered as a combined pump and feed-water heater the injector has a thermal efficiency of 100 per cent less the small loss due to radiation, since all the heat of the steam used passes into the water that is fed to the boiler.

However, where a feed-water heater can be employed, an injector is not so economical for feeding a boiler as a pump, since generally the injector can draw only cold or moderately warm water, while a pump can be used in combination with a feed-water heater where the feed water is heated by exhaust steam which otherwise would be wasted. Where all the exhaust of the pump can be thus utilized, its efficiency as a boiler feeder is practically as high as that of an injector, and the pump has the additional advantage of greater convenience in regulation of the output to the boiler requirements for feed water.

Copper Expansion Bends for Pipe Lines

We are considering the construction of a 6-in. pipe line for compressed air that would be under high pressure with the temperature about 350 deg. F. Are copper expansion bends suitable for such pipe lines?

C. A. M.

Copper disintegrates rapidly when subjected to high temperatures and repeated stresses. At ordinary temperatures the tensile strength is only about 30,000 lb. per sq.in. of cross-sectional area. At a temperature of 350 to 360 deg. F. its strength is reduced 15 per cent, and beyond 500 deg. F. the strength diminishes rapidly. On account of its resistance to corrosion and facility with which it may be made into intricate pipe-forms, copper formerly was used extensively for bends and connections for low pressure work, but with many serious failures, and its use for pipe line bends and connections has generally become superseded by mild steel, which has about twice the strength of copper and, from modern methods of production, is more reliable and cheaper.

Current Taken by a Motor at Reduced Voltage

According to Ohm's law the current in amperes varies directly as the applied voltage and inversely as the resistance in ohms. In other words, when the voltage increases the current increases in the same proportion if the resistance remains constant, or if the voltage is reduced the current decreases. If a 550-volt induction motor takes 125 amperes from the line to drive its load and the voltage is reduced, will the current be increased sufficiently to burn out the motor? J. K.

Ohm's law cannot be applied to a motor as to a resistance circuit without taking other factors into consideration. In a circuit having resistance only, the current in amperes is equal to the applied volts divided by the resistance in ohms. In the armature circuit of a direct-current motor or the stator circuit of an alternating-current motor the ohmic resistance is comparatively low, but a countervoltage is produced in these windings which is almost equal to the applied volts. It is the difference between the applied and counter voltages that is effective in causing the current to flow in the armature on stator windings. If the voltage applied to an induction motor is changed, there is a change in speed and magnetic flux to change the countervoltage, so that the motor can take a current under the new condition, sufficient to drive its load. If the load were to remain constant, the motor would have to develop constant horsepower and the power input would have to remain practically constant. Therefore if the voltage is reduced, the current will have to increase so that the motor can develop the necessary torque to drive the load. This means that a change will have to take place in the motor's speed and magnetic field that will reduce the countervoltage to a value where the applied voltage can cause a current to flow sufficient to drive the load. If the motor was operating at its rated voltage and load and the voltage was reduced materially, the current would increase beyond the rating of the motor, and although the motor might not be overloaded mechanically, it would be electrically, and this would cause excessive heating of the windings. If the voltage is reduced too far, it will be impossible for the motor to take sufficient current from the line to carry its load and it will

stop. The kind of load that the motor is driving will have a marked influence. If the motor is driving a conveyor, the torque will remain fairly constant, but if the motor is driving a fan the torque will decrease as the square of the speed. In the latter case the decrease in load due to decrease in speed when the voltage is reduced at the motor terminals, might be sufficient to prevent overloading the motor.

Measuring for New Connecting Rod

How would measurement be made for the length required for an engine connecting rod, neglecting the old one? R. K.

With the old connecting rod removed, set the piston rod in the crosshead at its position of central adjustment and see that the piston is set firmly on the piston rod. With the cylinder head in place, move the crosshead as far as it will go to bring the piston hard against one head of the cylinder and then the other, and each time make a mark on the piston-rod at the end of the stuffing-box gland. Make a mark on the piston rod halfway between these marks and move the crosshead to bring the middle mark on the piston rod at the end of the stuffing box gland. The crosshead and piston then will be at the middle of the stroke, and the required length for the connecting rod, center to center, will be the distance from the center line of the shaft to the center line of the crosshead pin. With the crosshead pin in place the distance can readily be measured by taking the distance with a rod from one side of the crosshead pin to the shaft center line, squared from the face of the crank, and adding to this distance one-half of the diameter of the crosshead pin.

Difference in Setting Single and Double Eccentric Corliss Engine Valves

What is the difference between valve setting of a single-eccentric and of a double-eccentric Corliss engine? R. L. M.

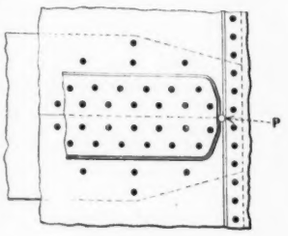
In the single-eccentric Corliss engine, the eccentric is set in advance of 90 deg. ahead of the crank, in order that the exhaust valves may open before the end of the admission stroke and close before the end of a return stroke, in place of obtaining compression by adjusting the exhaust valve rods when the wristplate is in central position, as that would retard the release and prevent full opening of those valves. With the single eccentric thus advanced, the wristplate is carried beyond its central position when the crank is on a center and lap must be given to the steam valves so they will not have more than the desired amount of lead; and as cut-off must occur before the wristplate has been carried to the limit of its oscillation to one side, advancing the eccentric ahead of the 90-deg. position of the crank for accommodation of the exhaust valves results in reducing the action of the cutoff to less than one-half stroke.

In a double-eccentric engine, one eccentric and wristplate are employed solely for controlling the exhaust valves in the same manner as in the single-eccentric engine, and there is an independent eccentric and wristplate for operation of the steam valves. If desired, the steam valves could be set without lap when the wristplate is in central position. Then with the eccentric set 90 deg. to the crank, the whole period of oscillation of the wristplate from central position to one side would be available for operation of the cut-off, i.e., during 90 deg. of rotation of the crank from dead center, or practically one-half of the stroke. In order to prolong the period of cut-off, it becomes necessary to have the stroke again begin earlier in the period of oscillation of the wristplate, or in other words, delay the swinging of the wristplate with reference to the crank by turning the eccentric backwards, thus imparting negative advance to the eccentric. When the engine is on a center the wristplate is thus behind its central position, and if the valves were set line on line with the wristplate in central position, they would lap over their ports at the beginning of a stroke and would be late in opening. Hence the steam-valve rods need to be adjusted so the valves will just begin to open, or have the desired amount of lead at the beginning of a stroke, and consequently the valves are open, that is have negative lap, when the wristplate is placed in the central position.

Permissible Filler in Boiler Joints

In good boiler construction is it permissible to use a "dutchman" for making up the joints? W. M. W.

The term "dutchman" is most commonly used disparagingly with reference to an odd piece of material used as a filler to hide a defect or cover bad workmanship. As such, a filler has no place in boiler construction or repairs. Patches exposed to the fire should be scarfed down and properly shaped for their junction with main plates to form good joints without the use of a filler. However, when very thick cover plates are used with horizontal joints, it is so difficult to tuck the ends of cover plates under the circumferential joints that the outside cover plate sometimes is cut short, as illustrated, leaving room for calking the ring seam and end of the cover plate, and a soft steel screw-plug *P* is inserted and calked to make a tight joint between the uncovered edges of the main plates. With large pitches and thick plates this use of a filler is satisfactory.



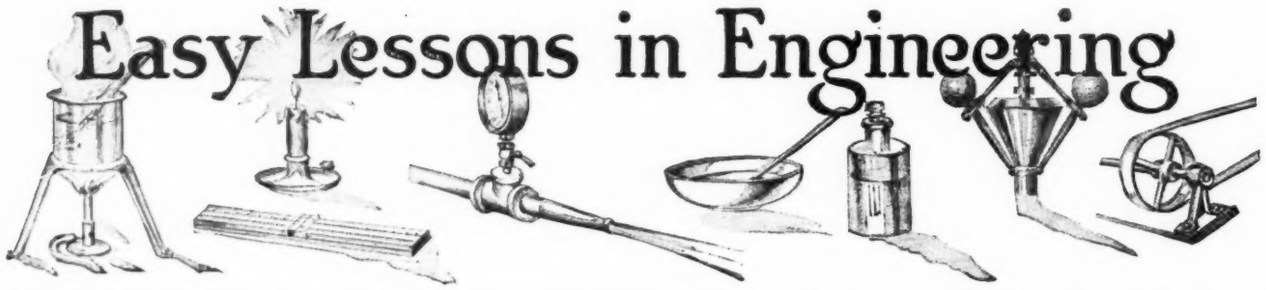
Removing Oil from Belts

What is a good method of removing oil from oil-soaked leather belting? If necessary for the purpose the belting can be temporarily removed from the pulleys. E. H.

Stretch the belt out flat on a floor covered with dry fine sawdust and remove all oil possible first from one side and then the other by a spreading of the sawdust swept off with a clean stiff broom and place the belt for a few days in a warm dry place packed in clean dry sawdust. One or two such treatments should remove enough oil to render the belt serviceable. When enough oil is present to moisten the faces of the pulleys, it can be removed by fixing a thin metallic scraper at an angle against one of the pulley faces to act like a skimmer from which the oil can be gathered on one side of the pulley. This method appears to remove oil from a belt by constantly presenting a cleaner space into which the oil is drawn as the belt leaves the pulley, with part of the oil deposited on the pulley.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Easy Lessons in Engineering



Over-All Plant Efficiency

As far as energy goes, and considering the steam-electric power plant as a whole, the input is the energy in the coal or other fuel and the output is the corresponding energy in the electricity produced.

The over-all plant performance may be expressed in a number of ways. The simplest expression for over-all performance, and generally the most important as well, is the weight of fuel used per kilowatt-hour. This figure does not show the real efficiency, since it takes no account of the heat value of the fuel. It does, however, tie in directly with the cost system, because with the ordinary method of purchasing fuel, money is spent not for heat units but for weight of fuel, so that the weight of fuel consumed per kilowatt-hour is a direct measure of the fuel cost per kilowatt-hour. But if the amount of fuel used per kilowatt-hour increases or decreases, the blame or praise should not necessarily fall on the operating force. They are using heat, not weight. If the fuel supplied falls off in heat value, they may properly use more of it.

So, in addition to the pounds of coal consumed per kilowatt-hour, it is important to know the over-all plant efficiency; that is, the ratio of plant output to plant input. This is easily figured if the heating value of the fuel is known, as well as the weight of fuel consumed per kilowatt-hour. Suppose the plant consumes 1.8 lb. of coal per kilowatt-hour and that the coal has a heating value of 13,400 B.t.u. The input per kilowatt-hour is then $1.8 \times 13{,}400 = 24{,}120$ B.t.u. And the corresponding output 3,412, since one kilowatt-hour is equal to 3,412 B.t.u. The efficiency must then be $\frac{3{,}412}{24{,}120} = 0.141$ or 14.1 per cent. That is to say, of all the heat in the coal fired only 14.1 per cent is delivered as electrical energy, the remainder going to waste up the stack, in radiation, friction, etc., but most of all in the exhaust of the prime mover.

This is on the assumption that the exhaust goes to waste. If any of the steam generated is used for heating purposes, whether this steam is taken directly from the boiler, from the turbine exhaust or from some intermediate bleeding point, the thermal efficiency as figured may have but little practical significance. A more logical way to figure the over-all efficiency of such a plant would be to include in the output the energy delivered outside as steam, as well as that in the electricity.

Suppose, for example, that a steam plant consumes 32,000 lb. of coal a day and delivers 8,500 kw.-hr. and dry saturated steam as follows: 46,000 lb. at 80 lb. gage pressure, and 195,000 lb. at 2 lb. gage pressure.

It may be imagined that the 80-lb. steam comes directly from the boiler through a reducing valve, while the 2-lb. steam is the exhaust from the turbine. The steam in both cases is dry and saturated at the point of measurement, it having first been desuperheated or passed through a separator according as it was originally superheated or wet.

Then taking one pound of coal as a basis, we find that for each pound of coal consumed the following is delivered outside the power plant:

Electricity (8,500 ÷ 32,000)	0.266 kw.-hr.
Steam at 80 lb. (46,000 ÷ 32,000)	1.44 lb.
Steam at 2 lb. (195,000 ÷ 32,000)	6.10 lb.

The heat equivalent of 0.266 kw.-hr. is $0.266 \times 3{,}412 = 907$ B.t.u. To get the heat equivalent of the steam supplied requires a little more calculation. The total heat of one pound of steam at 80 lb. gage (95 lb. absolute) is given in the steam table as 1,185 B.t.u., but this is not quite the proper credit to give per pound of steam furnished, because all steam-table heats are measured above 32 deg. F., which is a purely arbitrary point. Assume that all the process steam is condensed and trapped back to the power plant at 150 deg. Each pound of return water will then contain $150 - 32 = 118$ B.t.u., and the net heat furnished by the power plant for each pound of 80-lb. steam will be $1{,}185 - 118 = 1{,}067$ B.t.u. For 1.44 lb. the heat will be $1.44 \times 1{,}067 = 1{,}536$ B.t.u.

In the same way the net heat furnished in 6.1 lb. of steam at 2 lb. gage will be $6.1 \times (1{,}153 - 118) = 6.1 \times 1{,}035 = 6{,}314$ B.t.u. Then the useful output per pound of coal can be tabulated as follows:

	B.t.u.
Electricity	907
80-lb. steam	1,536
2-lb. steam	6,314
	8,757

If the heat value of the coal used is 13,400 B.t.u. per pound as fired, the overall efficiency of the plant, based on the grand total of useful output, is $\frac{8{,}757}{13{,}400} = 0.654$ or 65.4 per cent.

The question may arise as to what is the net heat delivered in exhaust or bled steam where the weight of returns is less than the total weight of steam delivered. Suppose, in the case just discussed, the returns were only 93,000 lb. per day or $93{,}000 \div 32{,}000 = 2.91$ lb. per lb. of fuel. The corresponding weights delivered are 1.44 lb. of 80-lb. steam and 6.10 lb. of 2-lb. steam, a total of 7.54 lb. The difference, $7.54 - 2.91 = 4.63$ lb. must come from raw makeup water, which we will say is obtainable in unlimited quantities at 60 deg. F. We may then credit the power plant with all the heat above 32 deg. F. in the steam supplied if we deduct the heat returned (also measured above 32 deg.) in 2.91 lb. of water at 150 deg. and 4.63 lb. at 60 deg. The net heat supplied in steam per pound of fuel will then be: $(1.44 \times 1{,}185) + (6.10 \times 1{,}153) - [2.91\ (150 - 32)] - [4.63\ (60 - 32)] = 1{,}706 + 7{,}033 - 343 - 130 = 8{,}739 - 473 = 8{,}266$ B.t.u.

Steam Chief Source of Middle Western Power

Although rich in coal deposits, large mouth-of-the-mine power plants will not constitute an appreciable source of power for the Middle Western industries; hydro-electric power will represent also, a comparatively small proportion, while steam plants built near the centers of industry, will in all probability furnish the greater part of energy for manufacturing purposes.

In a paper delivered recently by W. L. Abbott, before the Chicago Convention of the American Society of Civil Engineers, the author reviews this subject, referring to the territory extending from western Pennsylvania to eastern Kansas, and from southern Kentucky to the Great Lakes and the Canadian border. This comprises an area of 660,000 sq.mi. and a population of 40,000,000. It all lies in the Mississippi Valley and scarcely one per cent is rated as mountainous. Broad stretches of prairie and forest lands have, in general, such slight declivity and such absorbent soil that the water run-off, excepting that lost in floods, does not exceed one-fifth of the precipitation. Its placid streams, for the greater part of their courses, flow to the Great Lakes, or to the sea, with a slope of half a foot to the mile.

Such a gentle fall of natural watercourses makes relatively small water power possible. The various potential water power streams of the country are far removed from the coal mines. The States of Ohio, Indiana and Illinois, richest in coal, are poorest in water power. Only 18 per cent, or 776,000 kw. of water-power country, lies in the Middle Western States, the greater part of this being in Michigan, Wisconsin and Minnesota.

Hydro-electric power, and mouth-of-the-mine power plants, which are only possible in large degree remote from the Middle West, do not appear as favorable sources of power. The author points out that lack of condensing water, due to the comparatively small size of the streams in the coal-producing countries of the Middle West, makes large steam plants impossible. This is particularly true in the summer time, when large quantities of condensing water are necessary, on account of the high temperature, and streams are at the minimum of flow. Another reason is that the rail transmission of power by means of shipping coal is still cheaper than generation and wire transmission for long distances.

The author illustrates such conditions by assuming: A water-power site of 100,000 kw. and a coal mine, each distant from a large market of power; a steam electric plant that can be built for $120 per kw. of capacity, a water-power plant for $200 per kw. and a high-voltage double-tower transmission for $35,000 a mile; coal bought at the mine for $2.50 a ton, and a kilowatt-hour generated at 1.8 lb. of coal, with an annual load factor of 75 per cent. It is to be decided whether it will pay to develop water power to transmit energy, build a steam plant at the coal mine and transmit, or build a steam plant where power is to be used and ship coal from the mine. A table is worked out, computing the various costs, from which it appears that with coal at the quoted price, water power may be used up to a distance of 200 miles from the plant, beyond which coal shipped by freight would be preferable. A mouth-of-the-mine steam plant, with abundance of condensing water, would also be outclassed by a power house supplied by rail-borne coal, located in a big city 100 miles or more distant. The estimate includes a double tower line of two circuits, each on a private right of way.

Steam power is generated in this territory principally at Pittsburgh on the east, at Detroit and Chicago on the Great Lakes. To the north is the combined power of Milwaukee and Racine, together with some energy developed on the Wisconsin River at Kilbourn and Prairie du Sac. Northwest is the power of Minneapolis and St. Paul, and northeast is that of Duluth and West Superior. Going down the Mississippi River, the principal development is that of the three cities of Davenport, Moline and Rock Island, and farther down the water power at Keokuk. The greater part of this is used in St. Louis. Another great power center is at Kansas City and Joplin, Mo., together with Wichita, Kan., in the Southwest. In Indiana, Indianapolis, New Albany and Fort Wayne are among the largest power users. All over Ohio, Indiana, Michigan and Iowa, and to a lesser extent Wisconsin and Minnesota, small towns and villages are connected together with lines of less than 40,000 volts. One-sixth of this power is hydraulic and five-sixths steam.

The Middle West must continue to draw its own energy from its well-nigh inexhaustible coal beds and develop its power systems as in the past, by great power houses near the centers where power is used, linked together by power lines. This system, if completed, will offer a ready means of supplying power for railway electrification, which by all indications, is coming and soon.

Recovering the Waste Heat of Oil Engines*

The large heat losses in the case of steam plants are due to the change in the state of the working medium, to the large latent heat of steam and to the impracticability of feeding the boiler with exhaust steam. With steam-turbine machinery of high class, working under high pressure and a good vacuum, provided with superheaters, economizers, and all modern heat-saving appliances, the efficiency may reach 20 per cent. Such results were rarely, if ever, attained in practice even in very large installations and under the most favorable conditions. In the case of internal-combustion engines the thermal efficiency is greatly improved as compared with steam plants in consequence of the combustion taking place within instead of outside the working cylinder and by reason of the fact that no change in the state of the working medium occurs during the cycle.

In order to maintain the surfaces that were exposed to the heat of combustion at a safe working temperature, it is necessary to jacket them and to maintain a continuous circulation of water through the jackets. Part of the heat of combustion therefore, passes through the cylinder walls into the jacket water, performing no useful work, and thus forming one of the main losses of heat in the internal-combustion engines. Another serious heat loss is due to the temperature of the exhaust, and with no attempt at heat recovery in this respect over 30 per cent of the heat of combustion is wasted. This is valuable heat since it is at a high temperature, and not at a low temperature heat as is the jacket system. The actual amount of heat lost to the jackets and to the exhaust, expressed as a percentage of the heat contained in the fuel used, depends on the type of engine, its cycle, speed and size.

Several successful tubular heat boilers for generating steam under pressure from the exhaust gases of internal-combustion engines are on the market. By means of these boilers from 1½ to 3½ lb. of steam may be generated per brake-horse-power-hour of the engine at full load, the amount depending on the thermal efficiency of the engine and the percentage of the heat of combustion rejected to the exhaust.

It is essential, however, if the process is to be efficient, that the exhaust gases be led into the boiler with as little loss of radiant heat as possible. This means that the boiler should be placed in the closest possible proximity to the engine. It should be borne in mind in connection with the use of exhaust heat boilers that if the fuel holds any appreciable quantities of sulphur, the exhaust will contain sulphurous oxides which in the presence of moisture would form sulphuric acid. Although cast iron is fairly immune from attack, wrought iron or steel will be subjected to rapid corrosion.

Certain generating stations using internal-combustion engines have steam equipment and apply the exhaust from the former to heat the feed water for the latter. This makes a simple and inexpensive arrangement and enables about one-third to one-half of the exhaust heat at the economizer inlet to be recovered in the economizer. It may

*Extract of paper read before the Diesel Engine Users Association, by Eng. Commander W. P. Sillince.

not be out of place to mention that what is usually termed "loss to jacket water" frequently includes heat that should be debited to the "loss to exhaust," since the jackets receive heat not only during combustion and expansion but also during the exhaust stroke.

In the case of the Still engine it is claimed that all the heat usually lost through the jackets is recovered as well as a large percentage of that which passes out the exhaust pipe. The recovered heat is used to increase the output of the engine and to improve its efficiency without the use of additional fuel. The engine is manufactured as a four-stroke-cycle single-piston heavy-oil engine in sizes up to 1,000 b.-hp. for land purposes, and for marine propulsion it is being built as a two-stroke-cycle single-piston engine of about 350 b.hp. per cylinder. The principle is also being applied for locomotive purposes and in connection with semi-Diesel heavy-oil engines.

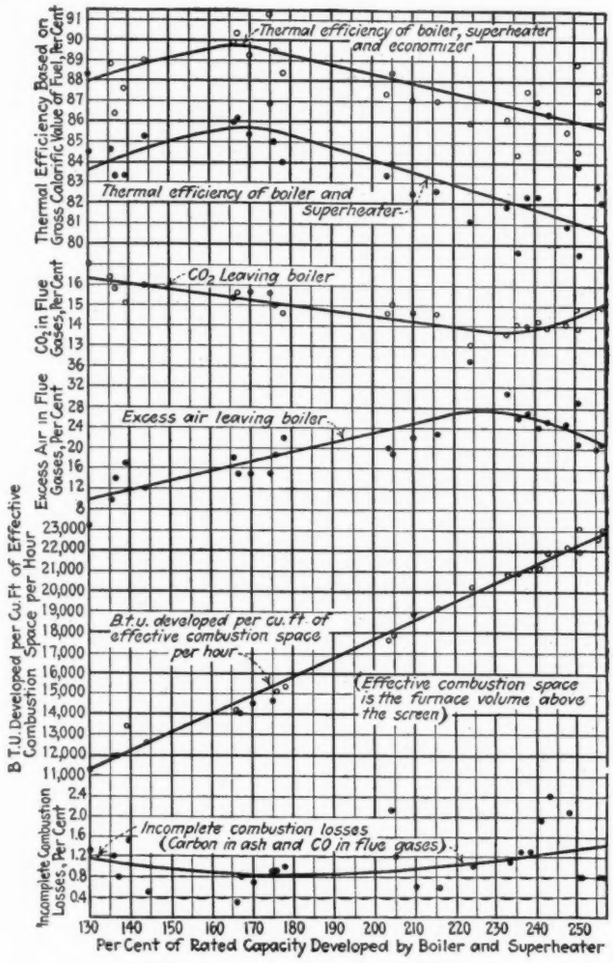
Combustion of Powdered Coal*

In a report of investigations published by the Bureau of Mines a review is given of some tests and results of observations conducted by the United States Bureau of Mines and the Combustion Engineering Corporation on boilers fired with powdered coal. The tests were conducted at the Lakeside Station of the Milwaukee Electric Railway & Light Co. A table of measurement of sizes and velocities is included in the paper which shows that the bulk of coal passing through a 200-mesh sieve has a mean diameter varying from 60 to 20 microns (0.0024 to 0.008 in.), also that when coal enters a furnace the vertical velocities of the widely different sizes of particles will vary, that the large particles will have the greater vertical velocity relative to the furnace gases and that this velocity increases with the temperature of the gases and the density of the particles.

This velocity of the particles relative to the air and furnace gases is of vital importance in burning powdered coal, since without it the coal would have to rely solely on diffusion for its supply of oxygen. Coal requires about 10,000 times its own volume of air at atmospheric temperature to form about 60,000 times its own volume of gas at furnace temperature, so that if a sphere of coal of 10 microns radius enters a furnace in a sphere of air at ordinary temperature just sufficient to burn it, this sphere of air will be over 210 microns in radius, and unless the mixture remains in the furnace for a considerable time or the coal is moved relatively to the air as described before, it will be impossible to burn it in the air, the bulk of which must come from the outer part of the sphere.

The coal enters through six burners situated in the top of the furnace.[1] The coal is brought to the burners through six pipes, mixed with about one-tenth of the total air supply needed for combustion, and with a velocity of about 100 to 150 ft. per sec., varying with the rate of combustion. The remainder of the air comes down vertically through openings around the burners and horizontally through ports in the front wall of the furnace. The horizontal velocity of the air tends to sweep the particles toward the back of the furnace and will cause the smaller particles to pass to the back with a greater velocity than the larger ones. Finally, the flame is carried vertically upward by the draft. Thus the flame is U-shaped, in which the larger particles, which require longer time to burn, are situated on its under and outer portion, dwell longer in the furnace and have a higher velocity relative to the gases in the furnace. As the coal particles burn, they gradually become smaller and their velocity relative to the furnace gases become less. Thus the longer path of the larger particles of coal makes them more nearly equal in size to the smaller particles having shorter path by the time all reach the upper parts of the rising arm of the U-shaped gas travel. The size of the furnace must be so proportioned to the maximum rate of combustion that practically all the coal particles are reduced to the ash residue by the time they reach the boiler.

The principal results of the tests are shown graphically in the illustration. The results are plotted on the rating developed by the boiler, and each point represents one test 24 hours long. The four lower curves are the most interesting from the viewpoint of combustion. The lowest curve gives the losses due to incomplete combustion, which includes CO in the flue gases as well as the unburned solid carbon carried by the gases out of the furnace. On most of the


Thermal efficiency of boiler, superheater and economizer
Thermal efficiency of boiler and superheater
Thermal Efficiency Based on Gross Calorific Value of Fuel, Per Cent
CO_2 Leaving boiler
CO_2 in Flue Gases, Per Cent
Excess air leaving boiler
Excess Air in Flue Gases, Per Cent
B.t.u. developed per cu. ft. of effective combustion space per hour
(Effective combustion space is the furnace volume above the screen)
B.T.U. Developed per Cu. Ft. of Effective Combustion Space per Hour
Incomplete combustion losses (Carbon in ash and CO in flue gases)
Incomplete Combustion Losses, Per Cent
Per Cent of Rated Capacity Developed by Boiler and Superheater

CURVES SHOWING SOME OF THE PRINCIPAL RESULTS

tests this loss was about 1 per cent of the heat in coal fired. At the lowest and also at the highest ratings the losses are nearly 2 per cent. The larger losses with the low ratings are probably due to low excess of air shown by the third curve from the bottom. At the high ratings the larger losses are probably due to the fact that the particles of coal passed faster through the furnace and did not have sufficient time to be burned completely.

The second curve shows that with the particular furnace the highest economical rate of heat evolution is about 23,000 B.t.u. per cubic foot of effective combustion space. If the rate of heat evolution were carried beyond this point, more particles of only partly burned coal would be carried out of the furnace with the gases.

The third curve from the bottom shows that with a furnace of the proper size powdered coal can be burned nearly completely with an excess of air of 10 to 25 per cent.

The highest two curves give the thermal efficiency of the furnace and boiler. The efficiency of boiler and superheater is well above 80 per cent and that including the economizer reaches 90 per cent, which is about the highest efficiency so far attained on a large power-plant steam-generating unit.

*Abstract of a paper presented before the American Chemical Society, Pittsburgh, Pa., Sept. 4-5, 1922. Published in the *Journal of Industrial and Engineering Chemistry*, March, 1923.

[1]See Dec. 19, 1922, issue of *Power*.

Vacuum Heating*

By J. E. Seiter

The use of a vacuum pump on the return lines of a building heating system was adopted originally for either or both of two reasons—to improve the circulation of steam in and the removal of condensation from the system, and to reduce the back pressure on the generating units in cases where exhaust steam was used for heating. More recently, it has been demonstrated that the use of a vacuum pump is productive of a considerable degree of economy in the consumption of steam. Of the heating systems under observation all have been of the vacuum return type and all are equipped with thermostatic traps on the radiators and riser drips.

When operated under a vacuum, the reducing valve on the steam supply has been set in each case so as to maintain a pressure below atmosphere in the radiators and piping, so that when vacuum is mentioned, the reference is to the vacuum at the reducing valve.

One of the greatest assets to a vacuum system is the positive circulation. This feature has a decided advantage, as it insures even distribution of heat throughout the building and especially in the morning when the steam is turned on after being shut off at night. This will allow the building to be heated up to temperature in the minimum amount of time in the morning, permitting the steam to be shut off for the maximum amount of time.

Naturally, a vacuum heating system has lower steam temperatures and consequently the condensate leaves the radiators at a lower temperature, thus utilizing this additional heat in heating the building. Aside from this feature the velocity of the condensate is greater through the return piping, permitting less cooling and assuring a higher temperature of the condensate entering the economizer or receiver.

In Detroit, mild weather with outside temperatures between 40 and 70 deg. F. constitutes about 50 per cent of each heating season, moderately cold weather with outside temperatures between 20 and 40 deg. F. about 45 per cent and only 5 per cent can be classed as "severely" cold. Necessarily, a heating system is designed so as to heat the Building properly during this severely cold weather.

In a straight steam system the temperature of the radiation cannot be varied and usually the only means of temperature control is by operating the radiator valves, which the occupants seldom do, consequently the building is overheated much of the time. By the use of a vacuum system it is possible to vary the temperature of the steam in the radiators considerably and thereby vary the rate of heat transfer. The range may be at least 30 per cent from 230 deg. F., corresponding to a steam pressure of 6 lb., to 170 deg., corresponding to a vacuum of 17 in.

Even in a system equipped with individual thermostatic control and the steam under pressure it is not probable that perfect regulation is obtained. When the temperature of the room reaches that set on the thermostat, it closes the valve on the radiator. This radiator is still full of steam and the large weight of metal in the radiator itself is at a temperature between 212 and 230 deg. F., which continues to radiate heat to the room, and the occupant becoming too warm, opens the window, cooling off the room sufficiently to cause the thermostat to open the radiator valve again.

If the building engineer avails himself of the opportunity to regulate the temperature of this steam by varying the pressure in the system, a considerable saving can be effected.

The distribution mains of any heating system are usually either in the attic or basement of the buildings. These places do not require much heat. Even though the piping is covered with ordinary covering, there still is a great loss of heat from these mains. Reducing the temperature of the steam reduces this loss. Aside from this the atmospheric or vapor systems which are much in vogue now, require oversized piping, because they are intended to circulate at a small pressure drop. With a vacuum system considerably greater pressure drops through the system are possible with a low initial pressure and the size of the piping can be reduced, thus cutting down the cost of the installation and the radiating surface of the piping.

Positive removal of air from the system guarantees good circulation and uniform temperatures. Aside from these factors the noiseless operation, the positive removal of the condensate and the absence of the most annoying part of many heating systems, the air valves, make a vacuum system desirable.

This system has some disadvantages, of course. The initial cost is high, it needs more attention than open systems, the maintenance cost is higher, and the desirability of duplicate pumps requires more floor space.

Good maintenance is important. The thermostatic traps must be watched and kept in good condition. The system must be kept tight to prevent excessive air leakage, which will reduce the vacuum. The system should never be allowed to get in such a state of repair so as to make jet water necessary to condense steam and vapor in the return lines. Jet water is undesirable and unnecessary in a properly maintained system in which a satisfactory type of thermostatic trap is used.

To determine the saving, if any, of operating under a vacuum, a test was run at the Washington Boulevard office of the Detroit Edison Co., a four-story brick building containing 200,000 cu.ft. of space. The heating system was re-designed and rebuilt by an experienced heating engineer in 1916, at which time it was remodeled into an overhead feed, thermostatically operated, two-pipe gravity system with thermostatic traps on all radiators. It contains 2,170 sq.ft. of direct radiation and 700 sq.ft. of indirect radiation, making a total of 6,400 sq.ft. of equivalent direct radiation. While the system was operating as well as any system of this type, the engineer of the company's service building, who is accustomed to a vacuum system, asked to have a vacuum pump installed.

Last summer this pump was installed, but before the

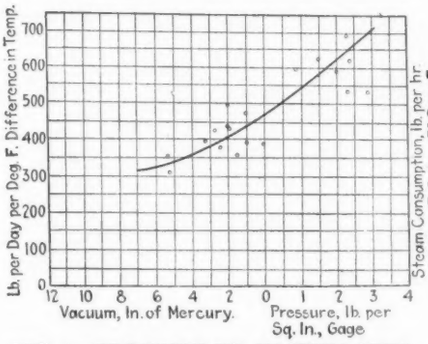


FIG. 1—PRESSURE VS. VACUUM OPERATION IN EDISON OFFICE BUILDING

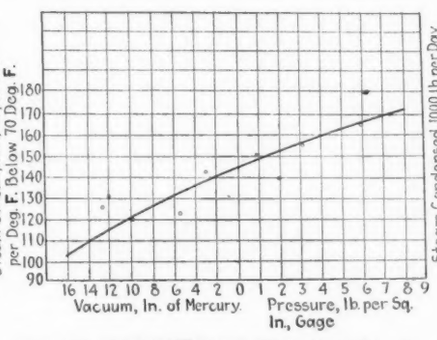


FIG. 2—PRESSURE VS. VACUUM OPERATION IN SERVICE BUILDING—EIGHT-HOUR TESTS FOR EACH POINT

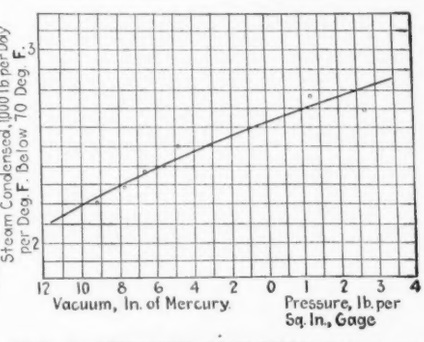


FIG. 3—SERVICE BUILDING DATA IN WHICH POINTS REPRESENT FIVE-DAY TESTS

*From report of Heat Utilization Committee of the National District Heating Association.

charges were completed it became necessary to use heat in the building and the ventilating equipment was not connected to the vacuum pump, which has therefore operated on the direct radiation only during the past winter.

This building is used by departments that have men working twenty-four hours a day. During the night the ventilating system is shut off, but the direct radiation is left on. During the past heating season the vacuum pump was run only during the day and the system was operated by gravity at night, as there was no engineer on duty during the night. A comparison of results before and after the vacuum pump was installed is given in the accompanying table.

SAVING EFFECTED BY VACUUM PUMP

Total steam from Oct. 1 to May 1, 1921-22, lb.	3,642,505
Total steam from Oct. 1 to May 1, 1922-23, corrected to temp. for 1921-22, lb.	3,297,500
Saving in seven months by using vacuum pump, lb.	345,000
Average saving per month, lb.	50,000
Estimated total saving for season by use of vacuum pump, lb.	395,000
Estimated total saving in dollars, with steam at $1 per 1,000 lb.	$395
Total actual cost of pump and piping installed	$658

The results by operating under pressure one week and vacuum the next are shown in Fig. 1. The points plotted indicate data obtained on days with the outside temperatures ranging from 25 to 35 deg. F. It was not possible with these outside temperatures to increase the vacuum much above 5 in. and still heat the building. The system is thermostatically operated and theoretically no saving should be shown, but actually it is marked.

During the heating season of 1921-22 tests were run at the Service Building to compare pressure and vacuum heating. This is a ten-story brick building, containing 40,000 sq.ft. of radiation. The system installed is an overhead feed, vacuum system, having all returns above the vacuum pump. The thermostatic equipment in the large general office rooms is of the so-called positive type in which the radiator valve is either wide open or tightly shut. In the smaller private offices the thermostats operate modulating valves permitting the radiators to heat fractionally.

The results of these tests are shown in Fig. 2. The points shown are for tests of eight hours each, during which the pressures were kept constant. The curve drawn through these points was obtained by calculating the steam consumption for various steam temperatures and a 70 deg. F. room temperature. It is interesting to notice how closely this curve fits in with the points obtained.

During the heating season 1922-23 the test was repeated to check these results by operating for longer periods than eight hours. The results are plotted in Fig. 3. The points are averages for periods of about five days each.

In all these tests the vacuum or pressure referred to was at the reducing valve and not at the pump. During all the tests the vacuum at the pump was maintained so as to give between 4 and 7 in. of mercury pressure drop through the system; that is, from the reducing valve to the pump.

Extremely high vacuums work well where there is piping large enough to supply sufficient steam to all radiators. The drop across the radiation traps can be as low as required approaching that of an atmospheric system. No cold-water jets were used or were necessary to maintain a high vacuum. No vapor was ever noticed around the meter. An economizer was used for heating domestic water, but was on the discharge side of the meter. Steam used for heating water was not considered in the tests.

The savings due to the use of a vacuum pump are not only theoretical but practical. The temperature control is easier, whether manual or mechanical. The circulation is better. The system is quieter and the low temperature of the radiator is more desirable.

Interpretations of the A.S.M.E. Boiler Code

REQUESTS for interpretations of the Boiler Code are acted upon by the Boiler Committee, their formulated replies being submitted to the Council of the American Society of Mechanical Engineers. The inquiries and replies are published from time to time in *Power*, with such explanatory comments and illustrations as seem advisable for a clear understanding of the interpretations on the part of engineers in general. The last group of interpretations published in *Power* was in the issue of June 19, 1923.

Case No. 414—Inquiry: Is it permissible, in the case of the flue of an internally fired boiler, which is corrugated for about half its length and the remainder plain, to calculate the thickness of the plain portion in accordance with Par. 239, assuming that the length of the plain portion is the distance from the center line of the rivets in the head to the beginning of the corrugations?

Reply: It is the opinion of the committee that in the calculation of the thickness of the plain portion of such a furnace, Par. 239b should be used, taking for the length, the distance from the face of the flange to the center of the first definite corrugation, and the thickness thus obtained shall be uniform throughout the entire length of the flue.

Par. 239b gives the following formula:

$$P = \frac{4{,}250 \times T^2}{L \times D}$$

where

P = Maximum allowable working pressure, lb. per sq.in.;
D = Outside diameter of furnace, in.;
L = Total length of furnace between centers of head rivet seams (not Length of a section), in.;
T = Thickness of furnace walls, in sixteenths of an inch.

This formula is for unstayed furnaces from 12 in. to 18 in. diameter, with length not more than 4½ diameters; also for furnaces more than 18 in. and not exceeding 38 in. in diameter. In no case is a thickness less than $\frac{5}{16}$ in. to be used. Where a furnace from 18 in. to 38 in. in diameter is over six diameters long, L in the formula shall be taken as six times the diameter.

Suppose, for example, that the furnace is 28 in. in diameter, $\frac{7}{16}$ in. thick and 108 in. long, of which 54 in. (measured from face of flange to center of first corrugation) is plain.

The values to substitute in the formula will then be:

$P = (?)$ $L = 54$ $T = 7$ $D = 28$

Substituting, we get for the allowable pressure:

$$P = \frac{4{,}250 \times 7 \times 7}{54 \times 28} = 138 \text{ lb.}$$

Case No. 416—(In the hands of the committee).

Case No. 418—Inquiry: Is it permissible, under the requirements of the Heating Boiler Section of the Code, to attach the safety valve to the pipe header outlet connection of a type of cast-iron sectional heating boiler with sections designed too narrow to admit of a separate opening on any one of them for the safety valve?

Reply: If the design of the boiler is such that it is not possible to form the safety-valve openings directly on the boiler sections, it is the opinion of the committee that the sections should be connected at two or more points to a manifold or header which will serve as a steam drum, and that it will be permissible to mount the safety valve on this manifold or header.

Case No. 419—(In the hands of the committee).

Case No. 420—Inquiry: Is it permissible, under the requirements of the Boiler Code, to drive up a blister or blisters on a tube or tubes of a water-tube boiler and reinforce them by depositing metal over the same by the autogenous process; or later, when other blisters appear above or below the first reinforcement, to use the same process again, increasing the length of the reinforcement; also to weld tubes lengthwise by the same process regardless of minimum or maximum length of weld for any thickness of tube and for any pressure without removing the tube from boiler or annealing the welding?

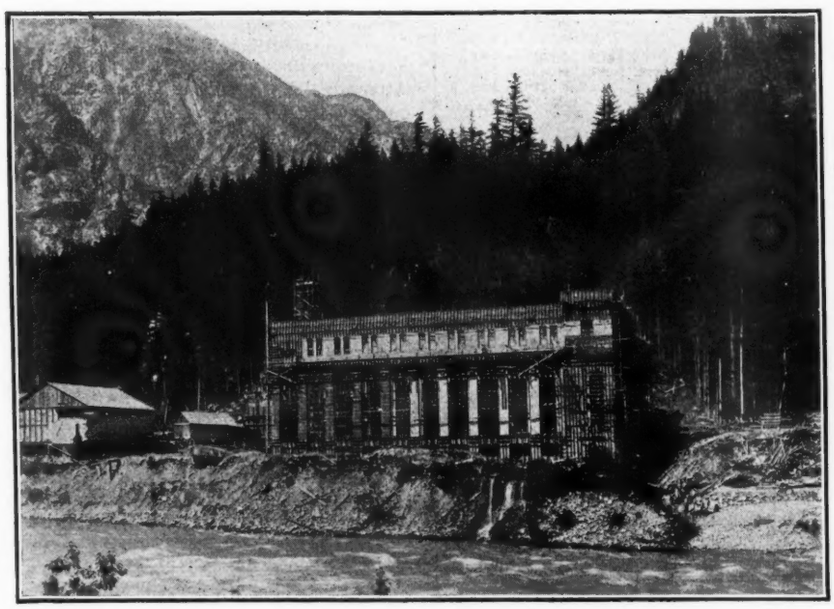
Reply: It is the opinion of the committee that such reinforcement or welding of blisters or other defects in the tubes of water-tube boilers would be analogous to the welding of cracks in shell plates subjects to tensile strain, which is prohibited under the Recommendations for Repairs by Welding in the Appendix of the 1918 Edition of the Code, page 127, third paragraph.

The paragraph referred to reads: "No welding shall be allowed in cracks in the shell plates or other plates subject to tensile strain."

News in the Field of Power

First Unit of Skagit River Development Nearing Completion

Construction work on the Gorge Creek plant of the Skagit River hydroelectric development of the City of Seattle is nearing completion, and it is expected to have the plant in operation by the first of the year. The plant, which is 100 miles north of Seattle on the Skagit River, will have an initial installation of two 20,000-kva. units operating under a head of 250 ft. As the demand for power increases, a third unit of 30,000 kva. will be added. The development consists of a concrete power house, an 11,000-ft. pressure tunnel and a rock-fill diversion dam.



FIRST UNIT IN SKAGIT RIVER DEVELOPMENT OF CITY OF SEATTLE

The tunnel is horseshoe shape, concrete lined, with an inside diameter of 20 ft. 6 in. and a capacity of 3,000 sec.-ft. at a velocity of 10 ft. per second.

The next step in the Skagit River development will be the construction of a 240-ft. concrete arch dam below the rock-fill dam, which will have a storage of 13,000 acre-ft. and increase the head on the plant to 375 ft. The runners in the turbines at the Gorge Creek plant will be changed at this time to operate efficiently under the increased head. As the plant will depend entirely at present upon stream flow, full capacity can be developed only under favorable water conditions.

A single-circuit wood pole tower 165,000-volt transmission line, 100 miles in length, will convey the power to Seattle, where a receiving substation will be built. The conductors will be 300,000 circ. mil copper equivalent, steel-core aluminum, and the line will have a capacity of 90,000 kva.

The final step in the Skagit River development will be the construction of the Ruby dam, ten miles above the power house now under construction. This dam will be 480 ft. high and will have a storage of about 1,300,000 acre-ft. In connection with this stage of the development a three-mile tunnel of 6,000 sec.-ft. capacity and a power plant with six 45,000-kva. units operating under a head of 720 ft. will be built. The estimated cost of the completed project is about $57,000,000. The cost of the first unit now under construction will be approximately $10,000,000.

New Boiler and Elevator Laws for Pennsylvania

The Pennsylvania Legislature passed during the past session two laws pertaining to the collection of fees for services rendered by the Department of Labor and Industry covering boilers and elevators.

The Boiler Law provides for the inspection of boilers by representatives of insurance companies and by salaried employes of the Department of Labor and Industry. Owners and users of boilers will be required to forward to the Department of Labor and Industry a fee of one dollar before the annual certificate of operation for the boiler will be issued.

When boilers are inspected by representatives of the Department of Labor and Industry, a fee of $6.50 will be collected for each external and internal inspection made while the boiler is not under pressure, and $2.50 for external inspection made when the boiler is under pressure.

Persons desiring to take examination for boiler inspector are required to pay a fee of $10 at the time of making application for examination. If the applicant is successful in passing the examination, a certificate of competency and a commission card will be issued without further charge.

The Elevator Law provides for the payment of a yearly fee of $1 for the certificate of operation which is required to be posted in the elevator car. No charges for inspection of elevators by employees of the Department to be made.

Persons desiring to take the examination for elevator inspector are required to pay $10 when filing their application for examination. If the applicant is successful in passing the examination, a certificate of competency will be issued, for which a fee of $5 is charged. A commission card to be used as a credential card will be issued annually to all approved elevator inspectors upon the receipt of a fee of $3.

It is the plan of the Department to put this law into effect as soon as the necessary forms can be printed.

Striking Against the Public

The *New York Times* concludes an editorial on the coal situation as follows:

Ultimately, the whole matter will have to be dealt with on larger lines. Something will have to be done, some form of legislation will be required, to free the country from the repeated menace of a coal strike. We have here incontrovertibly a public utility about the regulation of which the public is entitled to a voice. In failing to provide for this, Legislatures have been short-sighted and Congress has been timid and negligent. But the issue cannot be forever staved off. We may flounder through again this year, as we did last, with more or less suffering and a great deal of inconvenience, but the threat of trouble will keep on staring us in the face until some measures are taken to relieve us from the need of taking it into all our business and family reck-

onings year after year. Even if we make a narrow escape from disaster this year, Congress will be in a more chastened and responsive mood next winter, and the Administration should not fail to urge the enactment of laws that would free the country for years to come from this nightmare of recurring coal strikes.

Bureau of Mines To Start Peat Investigation

The Bureau of Mines is planning to begin an investigation of the peat deposits of the United States. At the request of Senator Fletcher, this will include an inquiry to determine whether peat exists, and to what extent, under the soil of Florida.

The bureau has on hand approximately $50,000 from an appropriation for investigation of lignite and peat. Attention thus far has been devoted to lignite, principally in the Dakotas, the matter of peat having been delayed, owing to inquiries into that subject by several European countries, to determine the value of their deposits for fuel and for extraction of by-products, so that this experience might be available to this country as a foundation for its work.

Details of the peat investigation will be worked out in the next few months and work will begin, in the South, probably this winter.

Steam Turbines and Electric Generators Exported

Figures given out by the Bureau of Foreign and Domestic Commerce show that there was exported during the first six months of 1923, from the United States, 38 steam turbines, 10,619 direct-current electric generators under 500 kw. capacity, 266 direct-current electric generators of 500 kw. and over, 116 alternating-current electric generators of 200 kw. and over.

Canada has been buying the greatest number of steam turbines with Japan coming second. Canada also purchased the greatest number of direct-current electric generators, while Japan was the largest buyer of alternating-current generators, having purchased 21 out of the total of thirty exported. The other orders for alternating-current generators have been scattered, France being the only country buying more than one.

Teachers of Engineering Spend July at Westinghouse Works

Twenty-one teachers of engineering, spent July in the East Pittsburgh works of the Westinghouse Electric & Manufacturing Co., renewing their contract with industry in the interest of better teaching.

Most of the mornings and many of the evenings were given over to conferences of technical and general policies nature. Each man was assigned to the department or section of the works in which he would come in contact with the men who could best give him what he wanted.

This is the thirteenth consecutive season that groups of engineering teachers have gathered at the Westinghouse plant for purposes of keeping in touch with new developments in industrial engineering.

Coming Conventions

American Chemical Society, Dr. Charles L. Parsons, 1709 G St. N. W., Washington, D. C. Convention at Milwaukee, Wis., Sept. 10-14.

American Institute of Electrical Engineers, F. L. Hutchinson, 29 West 39th St., New York City. Pacific Coast Convention at Del Monte, Calif., Oct. 2-5.

American Society of Mechanical Engineers, Calvin W. Rice, 29 West 39th St., New York City. Annual meeting at New York City, Dec. 3-6.

American Society of Refrigerating Engineers, William H. Ross, 35 Warren St., New York City. Nineteenth Annual Convention at New York City, Dec. 3-5.

Association of Iron & Steel Electrical Engineers; J. F. Kelly, 1007 Empire Bldg., Pittsburgh, Pa. Iron and Steel Exposition at Buffalo, N. Y., Sept. 24-28.

Electric Power Club, S. N. Clarkson, 900 B. F. Keith Bldg., Cleveland. Fall meeting at French Lick Springs Hotel, French Lick, Ind. Nov. 19-22.

Empire State Gas & Electric Association, Charles H. B. Chapin, Grand Central Terminal Bldg., New York City. Meeting at Lake Placid, N. Y., Oct. 8-9.

Illuminating Engineering Society, H. E. Mahan, Schenectady, N. Y. Convention at Fort William Henry Hotel, Lake George, N. Y., Sept. 24-28.

Indiana Electric Light Association, T. Donahue, Northern Indiana Gas & Electric Co., Lafayette, Ind. Meeting at French Lick Springs, Ind., Sept. 26-29.

International Union of Steam and Operating Engineers; Dave Evans, 6334, Yale Ave., Chicago, Ill. Annual convention at Detroit, Sept. 10-15.

National Association of Practical Refrigerating Engineers; Ed. H. Fox, 5707 W. Lake St., Chicago. Fourteenth Annual Convention at Memphis, Dec. 12-16.

National Association of Stationary Engineers; Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Buffalo, N. Y., Sept. 10-15. Annual conventions and exhibitions of the State Associations scheduled as follows: **Pennsylvania,** at Buffalo, Sept. 9-10; J. N. Calvert, Crafton Sta., Pittsburgh, Pa. **New York,** at Buffalo, Sept. 9-10; W. T. Meinzer, Third St., near Warburton, Bayside, L. I., N. Y.

National Exposition of Power and Mechanical Engineering; Charles F. Roth, Room 1102, Grand Central Palace, New York City. Power Show, Dec. 3-8.

National Safety Council, W. H. Cameron, 168 North Michigan Ave., Chicago, Ill. Twelfth annual congress at the New Statler Hotel, Buffalo, N. Y., Oct. 1-5.

New England Association of Commercial Engineers; James F. Morgan, 53 Devonshire St., Boston, Mass. Power Show at Mechanics Bldg., Boston, Mass., Oct. 29-Nov. 3.

New England Water Works Association; Frank J. Gifford, 715 Tremont Temple, Boston, Mass. Annual Convention at Burlington, Vermont, Sept. 18-21.

Society of Naval Architects and Marine Engineers, Daniel H. Cox, 29 West 39th St., New York City. Annual meeting at New York City, Nov. 8-9.

West Virginia-Kentucky Association of Mine, Mechanical and Electrical Engineers; Herbert Smith, Room 211, Robson-Prichard Bldg., Huntington, W. Va. Third annual convention at Frederick Hotel, Huntington, W. Va., Oct. 19-20.

Society Affairs

The Detroit Engineering Society announces that its campaign for a more suitable home has been crowned with success. Sufficient funds have been raised to take over property at 478 West Alexandrine Ave., and although alterations are in progress now, it is expected that the club house will be ready for occupancy during the last of September or the first of October. E. L. Brandt has been engaged as managing secretary.

The American Chemical Society, which meets in Milwaukee Sept. 10-14, has on its program several papers of interest to *Power* readers, as follows: "Loss of Heating Value of Bituminous Coal," by John F. Bryne and J. D. Davis; "Calculation of the Amount of Water in Producer Gas from the Orsat Analysis," by R. T. Haslam; "An Accurate Method for the Determination of Heats of Vaporization of Liquids," by J. H. Mathews; "The Specific Heats of Lubricating Oils," by E. H. Leslie & J. C. Geniesse; "The Effect of Oiliness of the Behavior of Journal Bearings," by D. P. Barnard, 4th, H. M. Myers and H. O. Forrest; "A Study of Viscosities of Fuel Oil Made from Pannco Crude," by R. H. Brownlie & W. H. Colburn.

Obituary

Charles Crocker Bussey, a prominent chemist of Brooklyn, N. Y., died on August 26 at Canaan, Maine. He was the inventor of the Bussey process, which, after many years of experimenting, had reached successful commercialization just recently, and constituted a great economic advance in the method of low temperature distillation of coals for the production of oil, coke, distillates and gas from bituminous coals, cannels, lignites and oil shales.

Mr. Bussey was born Jan. 16, 1866, in Newburgh, Maine, and received his early education in local schools and Bucksport Seminary. He graduated from the Massachusetts Institute of Technology in 1895 and entered the foundry business, later becoming associated with the Worthington Pump Co. During the World War he carried on extensive experimental work under the War and Navy departments for the production of tutuol and fuel oil. Mr. Bussey was a member of the A.S.M.E. for many years. He leaves a widow and a son, 9 years of age.

Personal Mention

M. W. Ward, formerly with the Sims Co., is now connected with the American Sterilizer Co., Erie, Pa., as consulting engineer.

Magnus W. Alexander, managing director of the National Industrial Conference Board, has recently returned from studying economic conditions in Europe. While there he addressed several meetings of industrialists in Englang, Germany and Austria.

Roy C. Masters, formerly assistant to the president of the Edward Valve Manufacturing Co., has allied himself with the Continental Valve & Equipment Co., 80 E. Jackson Boulevard, Chicago, Ill., manufacturers of and dealers in high-pressure valves, fittings and other auxiliary power-plant equipment.

H. S. Demarest, of Green, Tweed & Co., was the recipient, on July 17, of a cross of the order of *Polonia Restituta* (Resurrected Poland), bestowed by the Polish Government to him, in recognition of his services connected with the activities of the American Polish Chamber of Commerce, in the development of trade relations between America and Poland.

G. R. McDermott, assistant chief engineer, Illinois Steel Co., Chicago, Ill., and chairman of the Combustion Committee of the American Iron and Steel Electrical Engineers, together with **Charles L. Kinney, Jr.,** superintendent of No. 1 Openhearth, of the same company, were awarded the Sir Robert Hadfield $1,000 prize for the best paper presented before any engineering society in the United States on fuel conservation as applied to the iron and steel industry. The funds for this award were established four years ago by Sir Robert Hadfield of England to encourage research in the iron and steel industry, but this is the first award that has been made.

Robert H. Fernald has been designated by Governor Pinchot as engineer member of the Giant Power Survey Board. Mr. Fernald is a member of the A.S.M.E., President of the Philadelphia Engineers' Club and director of the mechanical engineering department of the University of Pennsylvania.

Trade Catalogs

Buckets—Blaw-Knox Co., Pittsburgh, installations, tables of specifications Pa. Bulletin No. 812 gives pictures of and dimensions as well as full descriptions of single line buckets.

Motors, Adjustable Speed—Reliance Electric & Engineering Co., Cleveland, Ohio, Bulletin No. 1014, contains descriptive matter and illustrations of type AS Reliance adjustable speed motor of the armature shifting design. Cross-sectional views, curves, tables of ratings and dimensions add to the value of this bulletin.

Steam Specialties—Atwood & Morrill Co., Salem, Mass., Catalog E, describes and shows by means of illustrations, valves, regulators, governors and other appliances. Tables of United States Standard flanges and a price list give value to this 44-page catalog. Catalog D describes exhaust steam valves for turbine and condenser service.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Aug. 27, 1923	Sept. 1, 1923
Pool 1,	New York	$3.00@3.50	$3.00@3.50
Smokeless,	Columbus	2.75@3.25	2.75@3.25
Clearfield,	Boston	1.90@2.50	1.90@2.50
Somerset,	Boston	2.25@2.75	2.25@2.75
Kanawha,	Columbus	1.75@2.00	1.75@2.10
Hocking,	Columbus	1.75@2.00	1.75@2.00
Pittsburgh No. 8	Cleveland	2.10@2.15	2.10@2.15
Franklin, Ill.	Chicago	2.75@3.25	2.75@3.25
Central, Ill.	Chicago	2.10@2.35	2.10@2.35
Ind. 4th Vein,	Chicago	2.50@2.75	2.50@2.75
West Ky.,	Louisville	1.95@2.05	1.85@2.00
S. E. Ky.,	Louisville	1.50@2.25	1.75@2.25
Big Seam,	Birmingham	1.75@2.15	1.75@2.15

FUEL OIL

New York—Sept. 6, light oil, tank car lots, 28@34 deg. Baumé, 4c. per gal.; 36@40 deg. 4¼c. per gal., f.o.b. Bayonne, N. J.

Chicago — Aug. 15, 24@26 deg. Baumé, $1.81½@1.86½ per bbl.; 32@36 deg., $2.01½@2.06½ per bbl., tanks cars.

St. Louis—Sept. 4, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.85 per bbl.; 26@28 deg., $1.90; 28@30 deg., $2.00; 32@36 deg., gas oil, $2.25; 36@40 deg., distillate, $2.40@2.45.

Pittsburgh—Aug. 24, f.o.b. local refinery, 30@34 deg., fuel oil, 4⅝c. per gal.; 36@40 deg., fuel oil, 4¾c.; 34 deg., neutral 7c.

Dallas—Sept. 1, f.o.b. local refinery, 26@30 deg., $1.36 per bbl.

Cincinnati — Sept. 4, tank-car lots f.o.b. local refinery, 26@30 deg. Baumé, 4¼c. per gal.; 30@32 deg., 4½c.; 38@42 deg., distillate, 5⅜c.

Philadelphia—Aug. 29, 26@28 deg., $2@2.10 per bbl.; 16@20 deg., $1.78@1.85; 14@16 deg., $1.60@1.66½.

New Plant Construction

PROPOSED WORK

Ala., Montgomery — The Office of the United States Engineer will receive bids until Oct. 1 for furnishing one steam boiler, with fixtures, stack, etc., for United States Dredge Upatoi at Columbus, Ga.

Ark., Little Rock—The Arkansas Power Corp. is having plans prepared and will soon receive bids for the construction of a dam on the Little Red River near here, power house to contain 7,500 sq.ft. of floor space, four head gates, fourteen tainter gates, racks, supports, one electric crane, 4 penstocks, 3 water wheels, 3 generators with exciters and switchboards, also 15,000 kva. step-up station at dam. Estimated cost $1,787,600. Dickinson & Watkins, Boyle Bldg., Little Rock, Engrs.

Calif., Pasadena—The Pacific Southwest Trust & Savings Bank is receiving bids for the construction of a 10 story, 105 x 168 ft. bank and office building on Marengo and Colorado Sts. Estimated cost $1,300,000. Curlett & Beelman, 408 Union Bank Bldg., Los Angeles, Archts. Noted Apr. 24.

Calif., San Francisco—L. J. Devlin, Archt., Pacific Bldg., is receiving bids for the construction of a 2 story laundry building on Filbert St. and Van Ness Ave., also for power plant equipment, heating system, etc., for the Roman Catholic Archbishop of San Francisco, 1100 Franklin St.

Fla., Delray — The city voted $50,000 bonds for improvements, including $22,000 for an additional engine, dynamo and other electrical equipment and extensions for water and light plant, etc.

Ill., Decatur — The Polar Wave Ice & Fuel Co., 3626 Olive St., St. Louis, Mo., is having preliminary plans prepared for the construction of a 2 story, 100 x 200 ft. ice manufacturing and refrigeration plant along tracks of the Wabash Ry., here. Estimated cost $150,000. H. G. Clymer, Wainwright Bldg., St. Louis, Archt.

Ill., East Alton—The Western Cartridge Co. is in the market for a 165 hp. steam boiler, 150 lb. working pressure, type similar to Erie City Economic or Scotch Marine.

Ky., Louisville — The Office of United States Engineer, P. O. Box 72, is in the market for one 50 hp., 550 volt, shunt wound, d.c. 1,200 r.p.m. vertical motor to drive vertical centrifugal pump; 75 hp., 550 volt, d.c., 450 r.p.m. and a 15 hp. 550 volt d.c., 850 r.p.m. vertical shunt wound motor with starting equipment. Cost will exceed $1,000.

Md., Baltimore—The Standard Electric Mchy. Co., 7-9 East Hill St., is in the market for a 1½ or 2 ton monorail hoist, 3 phase, 60 cycle, 220 volt, with or without trolley; 300 to 500 hp. slip ring motors, 3 phase, 60 cycle, any voltage and controllers.

Mass., Boston — J. A. Wetmore, Acting Supervising Archt., Treasury Dept., Wash., D. C., will receive bids until Sept. 26 for changes in lighting and ventilating systems in the United States Post Office and Sub-Treasury, here.

Mass., Everett—The Boston Elevated Ry. Co., 31 St. James Ave., Boston, will soon award the contract for the construction of a 75 x 100 ft. power house, pipe tunnel and steel track hopper. Estimated cost $50,000.

Mass., Lynn—The Eastern Machine Wks., 24 Marshall Wharf, is in the market for a high pressure oil pump, capacity 3,000 lb. per sq.in., 250 cu.in. per min.; weight type hydraulic accumulator, about 2 in. ram, 3,000 lb. capacity (used). Address the manager.

Mass., Stoneham (Boston P. O.)—The Commonwealth of Massachusetts, Metropolitan Dist. Com., 1 Ashburton Pl., Boston, will receive bids until Oct. 4 for construction and installation of a cross compound, crank and flywheel condensing pumping engine, capacity 20,000,000 g.p.d. for Spot Pond pumping station, here.

Mass., Taunton—The city, Municipal Light Dept., City Hall, is having plans prepared for the construction of a power house. Cost between $225,000 and $250,000. Jackson & Moreland, 387 Washington St., Boston, Engrs.

Mass., Wakefield—The Bd. of Light Comrs. will receive bids about Sept. 9 for the construction of a 1 story, 41 x 47 ft. addition to substation. Estimated cost $30,000. Lockwood, Greene & Co., 24 Federal St., Boston, Engrs. Bids will be taken on equipment at a later date. Noted Aug. 7.

Mich., Iron Mountain—The Ford Motor Co., Highland Park (Detroit P. O.), is having plans prepared for the construction of a 5 story, 112 x 140 ft. power house to contain four boilers, four 500 kw. turbo generators, exciter, pumps, etc., here. A. Kahn.

1000 Marquette Bldg., Archt., Detroit, Mich. The owner has awarded contracts for stokers, conveyors, turbo blowers, etc.

Mich., Lincoln Park (Wyandotte P. O.)—The Wayne County Road Com., Real Estate Exch. Bldg., Detroit, E. N. Hines, Chn., will soon award the contract for the construction of pumphouse with motor driven pumps, discharge lines, etc. Estimated cost $40,000. H. A. Shuptrime, c/o owner, Engr.

Mich., Trenton—The village, L. Frabes, Clk., will receive bids until Sept. 17 for the construction of a water purification plant and pumping station; intake and supply main; two motor driven centrifugal pumps, capacity 2,000,000 g.p.d. Hoad, Decker, Shoecraft & Drury, Ann Arbor, Engrs.

Mo., Breckenridge — The city is having preliminary plans and surveys made for a waterworks and sewer system, including pipe, pumps, etc. Cost will exceed $35,000. E. T. Archer & Co., New England Bldg., Kansas City, Engrs.

Mo., Cameron—The city plans a new election to vote $182,500 bonds including $53,433 for waterworks, $64,550 for electric light plant, $53,860 for sewers and additions, $11,945 for engineering and supervision. Burns & McDonnell, 401 Interstate Bldg., Kansas City, Engrs. Noted July 17.

Mo., Columbia — The city is having preliminary plans prepared for improvements to waterwerks and light plant, including increasing capacity of reservoir from 1,000,000 to 3,000,000 gal., additional pumping unit, boiler, air compressor and mains. Estimated cost $160,000.

Mo., Drexel—The city is having plans and surveys made for waterworks improvements, including dam, pumps, distribution mains, reservoir, 5,000,000 gal. capacity, etc. Estimated cost $25,000. J. P. Davis, Jefferson City, Engr.

Mo., Foley—The Bd. Supervisors, Sandy Creek Drainage Dist. will receive bids until Sept. 15 for the construction of a pumping station, either 16 x 24 ft. for vertical engines or 22 x 22 ft. for horizontal engines, including foundations for engines; one 45 hp. oil engine; oil tank; one centrifugal pump, 7,500 g.p.m. capacity. T. N. Jacob, 1900 Railway Exch. Bldg., St. Louis, Engr.

N. J., Bordentown—Bids will be received at the office of the Commissioner of Educ., State House, Trenton, Sept. 27, for the construction of a 16 x 22 ft. pump house, c.i. mains and alterations for addition to the water supply system at the Bordentown Manual Training & Industrial School, here. N. S. Hill, Jr., 112 East 19th St., New York Consult. Engr.

N. Y., Binghamton—The Cutler Ice Co., Front St., I. H. Thomas, Pres., plans to build an addition to its plant and is in the market for equipment, 30 ton capacity. Estimated cost $50,000.

N. Y., Potsdam—The village is having plans prepared and will soon receive bids for the construction of a filtration plant on the Raquette River. Estimated cost $100,000. C. A. Pohl, 30 Church St., New York, Engr.

N. C., Rougemont—A. Carver is in the market for waterwheels, governors, etc., to develop 100 hp. hydro-electric plant.

N. D., Mandan—The city is in the market for one 350 gal. pump for water department.

Ohio, Fostoria—The Exchange Club plans to build a hospital, nurses' home, laundry and power house. Estimated cost $100,000. Engineer or architect not selected.

Tenn., Knoxville — The Duncan Mchy. Co., Dempster Bldg., 721 North Central Ave., J. G. Duncan, Purch. Agt., is in the market for 25 and 30 hp. engines.

Tenn., Lawrenceburg—The city has had plans prepared and will soon receive bids for the construction of a hydro-electric dam for light plant. Estimated cost $80,000. Freeland, Roberts & Co., Independent Life Bldg., Nashville, Engrs. Noted Aug. 14.

Tex., Dallas — The Texas Farm Labor Union, c/o R. R. Claridge, Bonham, plans to build a warehouse and cold storage plant, here. Cost will exceed $40,000. Engineer or architect not announced.

Va., City Point—The Wilson Hock Co. is in the market for three out door transformers, capacity 500 kva. each, 13,200 volt high tension, 2,200 volt high tension; also six 60 cycle transformers requiring winding.

Va., Richmond—The city, B. H. Grundy, Chn. Finance Com., plans a $3,000,000 bond issue for harnessing Shockoe Creek to prevent damage by freshets. A. J. Saville, Dir. Public Wks.

W. Va., Huntington—The State Bd. Control, Charleston, J. S. Lakin, Pres., will receive bids until Sept. 28 for the construction of a 1 story, 58 x 94 ft. hospital recreation building and a 3 story, 121 x 163 ft. dormitory, here. R. M. Bates, Huntington, Archt. The owner will award the contract for heating and ventilating apparatus.

W. Va., Logan — The Guyan Machine Shops, B. Shell, Mgr., are in the market for 1 to 20 kw., 110 to 220 volt transformers with hangers and lightning arresters; natural gas burners for hot water furnace with 36 x 84 in. door for burning soft coal; high speed elevator, about 1,000 lb. capacity, operated from platform, electric drive, 220 volt, 60 cycle, for 3 story building.

Wis., Cobb—The Cobb Canning Co., W. Sink, Pres., is receiving bids for two 100 hp. boilers, 80 ft. smokestack, steel for factory building and pumping equipment for deep well water supply. Estimated cost $25,000.

Wis., Dodgeville — Perkins Bros. (meats and produce) are in the market for motor driven refrigeration machinery, several ton capacity.

Wis., Fond du Lac—G. A. Stanchfield, Engr., City Hall, is preparing plans and will soon receive bids for the installation of one 20 in. and one 10 in. centrifugal pump, also addition to septic sewer tank.

Wis., Janesville—Rock County, c/o M. L. Paulson, Evansville, Chn. Bldg. Com., is having plans prepared for the construction of a 1 story, 50 x 90 ft. boiler house, here. Estimated cost $40,000. E. E. Dillon, Washington Bldg., Madison, Engr. The owner is in the market for coal handling equipment and several tubular boilers.

Wis., Madison—F. L. Kronenberg, Engr., Carroll Block, is receiving bids for a steam heating plant, including boilers, in store building for J. McCarthy, 401 Atwood Ave.

Wis., Milwaukee — The Sewerage Comn., 508 Market St., J. H. Fowles, Secy., will receive bids until Sept. 14 for steam heating systems for power and boiler plants on Jones Island. Cost exceeds $40,000. T. C. Hatton, c/o owner, Engr.

Wis., Milwaukee—The Wisconsin Public Service Corp., 559 Marshall St., will receive bids until Sept. 15 for a switchboard, supervising control, and power transformers for hydro-electric plant at Caldron Falls. Mead & Seastone, Journal Bldg., Madison, Engrs.

Wis., Sheboygan—E. A. Juul, Archt., Security Bldg., is receiving bids for the construction of a 4 story, 65 x 140 ft. factory, including boiler room, etc., for the Bemis-Riddel Fibre Co., 150 Illinois Ave. Estimated cost $40,000.

Wis., Sheboygan—The Sheboygan Mattress Co., 1214 Michigan Ave., is having plans prepared for a steam heating plant, including boilers, for store and factory. Estimated cost $25,000. E. A. Juul, Security Bldg., Sheboygan, Engr.

CONTRACTS AWARDED

Calif., Long Beach—Canterbury & Bradford awarded the contract for the construction of an 11 story, 110 x 270 ft. apartment house on Ocean Ave. and 3rd Pl. to the Ransford-Goble Co., 1643 Highland Ave., Los Angeles. Estimated cost $1,000,000. Equipment detail not reported.

Ky., Danville — The Kentucky Hydro-Electric Co., c/o A. Graham, Middlewest Utilities Co., 122 South Michigan Ave., Chicago, awarded the contract for the construction of a 260 ft. dam two miles from the mouth of the Dix River, near here, to L. E. Meyer, Monadnock Bldg., Chicago. Estimated cost $4,000,000. Noted July 17.

Mo., King City—The city awarded the contract for c.i. pipe, hydrants, gate valves, boxes, one 75,000 gal. water tower, 125 ft. high, 14 x 28 ft. well, pumphouse and one 165 g.p.m. triplex pump with motor to the Beeson Mchy. Co., 308 Mutual Bldg., Kansas City. Noted June 26.

N. Y., Brooklyn — The Bd. Educ., 500 Park Ave., New York, awarded the contract for the construction of P. S. 196 on Bushwick Ave. to the Lustbader Constr. Co., 423 Madison Ave., New York, $1,012,000, noted Apr. 17; high school on Classon Ave. between Union and President Sts. to G. A. Fuller, 175 5th Ave., New York, $2,492,000, noted Apr. 24. Equipment detail not reported.

N. Y., New York—The Bd. Educ., 500 Park Ave., awarded the contract for heating, ventilating and temperature regulating apparatus for Julia Richmond High School on 2nd Ave. and 67th St., to Gillis & Geoghegan, Inc., 537 West Broadway, New York, $268,630. Noted Aug. 21.

N. Y., New York—The K. C. W. Bldg. Co., c/o C. Kreymborg, Engr. and Archt., 2534 Madison Ave., will build a 146 x 211 ft. apartment house on West Tremont Ave. by day labor. Estimated cost $750,000. Equipment detail not reported.

N. Y., New York—H. & S. Sonn & Co., c/o Margon & Glaser, Engrs. and Archts., 2804 3rd Ave., will build a 14 story, 75 x 150 ft. apartment house at 112 East 39th St. by day labor. Equipment detail not reported.

N. Y., New York—Sugarman & Berger, Engrs. and Archts., 16 East 43rd St., awarded the contract for the construction of a 15 story, 76 x 118 ft. apartment house on Amsterdam Ave. and 73rd St. to J. G. Siegel, 345 Madison Ave., New York. Estimated cost $900,000. Equipment detail not reported.

Ohio, Cleveland—The Babies' & Children's Hospital, c/o D. Baldwin, Natl. City Bldg., awarded the contract for foundations for two 7 story, 60 x 151 ft. hospital buildings at 11020 Euclid Ave. to the Craig-Curtiss Co., 4614 Prospect Ave., Cleveland, $194,290. Total estimated cost $3,300,000.

Ohio, Cleveland—The United Banking & Savings Co., A. H. Seibig, Pres., awarded the contract for the construction of a 2 and 6 story, 60 x 110 ft. bank and office building on West 25th St. and Lorain Ave. to the Hunkin-Conkey Constr. Co., Century Bldg., Cleveland. Estimated cost $1,000,000. Steam heating system will be installed.

Ohio, Conneaut—The New York, Chicago & St. Louis R.R. Co., Columbia Bldg., Cleveland, awarded the contract for the construction of a coaling station, 500 ton capacity, here, to Roberts & Schaefer, 400 North Michigan Ave., Chicago. The owner is in the market for electric hoists, buckets and fixtures.

Pa., Phila.—The city awarded the contract for the construction of a sewage pumping station in the 40th Ward to the M. G. I. Constr. Co., Broad and Arch Sts., Phila., $174,132.

Tenn., Chattanooga — The Tennessee Power Co., Hamilton Natl. Bank Bldg., awarded the contract for steel for the construction of a power house at Hale's Bar, to the Converse Bridge & Steel Co., Anderson and Beckley Sts., Chattanooga. Estimated cost $38,000. Noted Apr. 3.

Tex., Sabinal—The City Com. awarded the contract for a 100,000 gal. steel tank and tower to the Pittsburgh-Des Moines Steel Co., Praetorian Bldg., Dallas. Estimated cost $40,000. Contract not awarded for pumping plant.

Wash., Seattle — The Community Hotel Corp. awarded the contract for the construction of the Hotel Olympic to Grant, Smith & Co., Henry Bldg., $3,254,000. This does not include contract for steel which has been purchased by the owner, $250,000. Noted June 19.

Wis., Cobb—The Cobb Canning Co., Markesan, W. Sink, Pres., awarded the contract for the construction of cannery, consisting of a 3 story, 40 x 100 ft. main building, 2 story, 60 x 110 ft. warehouse, 1 story, 40 x 42 ft. boiler house and a 40 x 44 ft. cook room to the H. J. Selmer Co., McCartney Natl. Bank Bldg., Green Bay. Estimated cost $100,000. The owner is in the market for conveying machinery, etc.

Wis., Horicon—The city, E. M. Higbee, Clk., awarded the contract for a steam heating plant, including boilers, in the City Hall, to the J. L. Brown & Son Co., Horicon. Noted Aug. 28.

Wis., Milwaukee—The Milwaukee Electric Ry. & Light Co., 2nd and Sycamore Sts., awarded the contract for the construction of a 2 story, 50 x 70 ft. boiler house on Edison Ave., to the P. W. Bringe Co., 940 3rd St., Milwaukee. Estimated cost $70,000. Noted Aug. 14.

Wis., Mosinee—The village awarded the contract for the construction of a 30 x 42 ft. pumping station to A. Barry, Mosinee. Estimated cost $18,000. Noted May 22.

Ont., Ford—The Ford Motor Co. of Canada awarded the contract for the construction of a 1 story, 144 x 200 ft. heat treating plant to Wells & Gray, Ltd., Ford. Estimated cost $500,000. The owner is in the market for special equipment for plant.

Ont., Hamilton — The Hamilton Hydro Comn., King St., E., awarded the contract for the construction of a substation on Beach Rd. to the W. H. Yates Constr. Co., 17 Main St., E., Hamilton, $43,100. The owner is in the market for $58,000 worth of transformers and general substation equipment. Noted Aug. 28.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

Declines—Structural and boiler rivets down 15c. per 100 lb. at Pittsburgh mill. Raw linseed oil quoted at 95c., against $1.05 per gal. (5 bbl. lots) f.o.b. New York. Underwriters' fire hose down 1½c. per ft. in month. Declines reported in refractories. Armored cable discounts heavier; the recent rapidly declining market in this commodity has about reached bottom and advances are expected. Rubber-covered copper wire down; reflecting drop in metal. Increased discounts also reported in brass shell sockets and enclosed knife switches.

Advances—Washed, white wiping cloths up ¾c. per lb. Cold finished shafting, flats, squares, hexagons, etc., advanced 25c. per 100 lb. in month. Babbitt metal 1c. per lb. higher in Cleveland.

POWER-PLANT SUPPLIES

HOSE—

	Fire	50-Ft. Lengths
Underwriters' 2½-in., coupled		51½c. per ft.
Common, 2½-in., 3-ply	$1.00 per ft. list less 40–10–5%	

	Air	
¾-in., per ft.	3-ply $0.33	4 ply $0.25

Steam—Discounts from List

First grade....40–5% Second grade....45% Third grade.....50%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 60–5% Best grade..... 50–10–5%

LEATHER BELTING—List price, 2c. per sq. in., per ply.

Grade	Discount from list
Medium	30–10%
Heavy	20–5–2½%

RAWHIDE LACING
- For cut, best grade, 40%, 2nd grade, 50%.
- For laces in sides, best, 48c. per sq.ft.; 2nd, 43c.
- Semi-tanned: cut, 40%; sides, 48c. per sq.ft.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam, ½ in.	$0.90
Asbestos for high-pressure steam, ½ in.	1.70
Duck and rubber for piston packing	.90
Flax, regular	1.10
Flax, waterproofed	1.70
Compressed asbestos sheet	.80
Wire insertion asbestos sheet	1.30
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.25
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.30
Asbestos wick, ½- and 1-lb. balls	.50

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia high pressure		50%
For low-pressure heating and return lines	4-ply	70%
	3-ply	72%
	2-ply	74%

PORTLAND CEMENT—New York, $2.70@ $2.80 per bbl. without bags, in carl ad lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.64 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York Current	Cleveland	Chicago
White	10.00@13.00	15.00	11.00
Colored	8.00@13.00	12.00	8.00

WIPING CLOTHS—Jobbers' prices, in cents per lb., as follows:

	13¼ x 13¼	13¼ x 20½
Chicago	10.00	13.00
New York	11.00	....
Cleveland	$36.00 per M.	$52.00 per M.

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$0.95	$1.18	$1.14

WHITE AND RED LEAD—In 100-lb. kegs, base price in cents per pound:

	Dry		In Oil	
	Current	1 Yr. Ago	Current	1 Yr. Ago
Red	14.00	12.50	15.50	14 00
White	14.00	12.50	14.00	12 50

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅛ and smaller	40%	50–10%	60%
Tinned	40%	50–10%	4½c. per lb. net

Structural rivets, ½ . ½, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.

New York.....$4.40 Chicago.....$3.75 Pittsburgh.... $3.00@3.25

Boiler rivets, same sizes:

New York.....$4.50 Chicago..... $3.85 Pittsburgh.... $3.10@3.35

REFRACTORIES—Prices in car lots f.o.b. plant:

Chrome brick, eastern shipping points	net ton	$50@55
Chrome cement, 40@ 50% Cr_2O_3, in bulk	net ton	27@32
Chrome cement, 40@50% Cr_2O_3, in sacks	net ton	31@36
Magnesite brick: 9-in. straights	net ton	65@68
Magnesite brick: 9-in. arches, wedges and keys	net ton	71.50@74.80
Magnesite brick: Soaps and spits	per ton	92.00@96.20
Silica brick: Mt. Union, Pa.	per M	45.00@46.50
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per M	45@52
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	45@46
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	45@46
Clay brick, 2nd quality, 9 in. shapes, Pennsylvania	per M	40@47
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	40@42
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	40@42
Chrome ore crude, 40@50%	net ton	20.00@25.50

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
(83% tin)	52.00	49.00	38.00
(35% tin)	25.00	17.00	16.00

COLD FINISHED STEEL—Warehouse prices are as follows:

	New York	Cleveland	Chicago
Round shafting and screw stock, per 100 lb. base	$4.65	$3.90	$4.55
Flats, square and hexagons, per 100 lb. base	5.15	4.40	5.05

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	60-10%
Boiler stay bolts	50%
Boiler patch bolts	10%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%
Pressed steel boiler hangers	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the latest Pittsburgh basing card:

BUTT WELD

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv.
1 to 3	62	50½	¼ to 1¼	30	13

LAP WELD

2	55	43½	2	23	7
2½ to 6	59	47½	2½ to 4	26	11
7 and 8	56	43½	4½ to 6	28	13
9 and 10	54	41½	7 to 12	26	11
11 and 12	53	40½			

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60	49½	¼ to 1½	30	14
2 and 3	61	50½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	53	42½	2	23	9
2½ to 4	57	46½	2½ to 4	29	15
4½ to 6	56	45½	4½ to 6	28	14
7 and 8	52	39½	7 and 8	21	7
9 and 10	45	32½	9 to 12	16	2
11 and 12	44	31½			

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
4	.....	.....	$0.23
3½	.....	.....	.25
3	.....	.....	.22
1¼	$0.26	$0.29	.23
1	.20	.25	.21
1¼	.23	.29	.23
1½	.24	.33	.28
2½	.....	.....	.....
2	.30	.41	.32
2¼	.32	.47	.35
2½	.34	.51	.37
2	.43	.64	.47

Tubes 2¼ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per lineal foot based on stock lengths. If cut to special engths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

1¼ in. to 2 in. diameter, 5c. per cut. 2½ in. diameter, 7c. per cut
2¼ in. diameter, 6c. per cut. 3 in. diameter, 9c. per cut
3¼ in. to 4 in. diameter, 10c.

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$ 43.00 (net)	$ 84.00 (net)	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:		Lead Covered
Less than coil lots	30%	15%
Coils to 1,000 ft.	40%	20%
1,000 to 5,000 ft.	45%	25%
5,000 ft. and over	45–5%	25–5%

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f.o.b. New York, with 10-day discount of 5 per cent.

Size In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplings Black Per C	Couplings Galvanized Per C
¼	$61.10	$66.16	$9.90	$11.03	$5.74	$6.16
¾	79.20	84.95	13.00	14.49	8.18	8.78
1	112.06	122.19	19.26	21.46	10.65	11.42
1¼	151.62	165.31	25.65	28.33	14.76	15.78
1½	181.28	197.67	34.19	37.77	18.23	19.47
2	248.90	265.94	62.70	69.24	24.29	25.97
2½	385.50	420.48	102.58	11.33	34.71	37.10
3	504.29	548.81	273.40	302.12	51.66	55.63
3½	633.86	688.65	604.03	667.15	69.41	74.19
4	772.62	838.59	697.06	770.99	86.76	92.73

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.10	D. P. D. B.	$0.32
D. P. M. L.	.16	T. P. S. B.	.30
T. P. M. L.	.24	T. P. D. B.	.42
D. P. S. B.	.18		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.39	$1.00	$2.10
T. P. M. L.	.60	1.47	2.80
D. P. S. B.	.49	1.26	.....
T. P. S. B.	.92	2.10	.....
D. P. D. B.	.89	2.46	.....
T. P. D. B.	1.57	4.20	.....
T. P. to D. P. D. B.	1.05	2.88	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy	$23.00
No. 16 cotton reinforced heavy	29.00
No. 18 cotton reinforced light	19.50
No. 16 cotton reinforced light	22.50
No. 18 cotton Canvasite cord	17.00
No. 16 cotton Canvasite cord	19.25

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.20	3-amp. to 30-amp.	100	$0.40
35-amp. to 60-amp.	100	.30	35-amp. to 60-amp.	100	.60
61-amp. to 100-amp.	50	.90	65-amp. to 100-amp.	50	1.50
101-amp. to 200-amp.	25	2.00	110-amp. to 200-amp.	25	2.50
201-amp. to 400-amp.	25	3.60	225-amp. to 400-amp.	25	5.50
401-amp. to 600-amp.	10	5.50	450-amp. to 600-amp.	10	8.00

Discount: Less 1-5th standard package, 55%; 1-5th to standard package, 60%; standard package, 65%.

RENEWABLE FUSES, ENCLOSED—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4.00	5.00	25	5
225 to 400-amp.	7.50	11.00	25	1
450 to 600-amp.	11.00	16.00	10	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package (500)	$2.70
0-30 ampere, less than standard package	3.00

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs or Bowl Enameled Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.32	$0.37	120	75	$0.55	$0.60	60
15	.32	.37	120	100	.70	.75	24
25	.32	.37	120	150	.90	.95	24
40	.32	.37	120	200	1.15	1.25	24
50	.32	.37	120	300	1.75	1.85	24
60	.37	.42	120				
				500	2.50	2.65	12
				750	3.75	4.00	8
				1,000	4.25	4.50	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.19
Composition 2-piece attachment plug	.29
Swivel attachment plug	.12

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York.

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$ 7.00	$ 9.50	$11.22	$18.00
12	10.00	12.10	13.20	23.40
10	13.20	15.90	17.90	30.20
8	18.00	21.60	23.80	40.17
6	.....	.....	33.50	.....
4	.....	.....	45.00	.....
2	.....	.....	66.25	.....
1	.....	.....	88.50	.....
0	.....	.....	112.50	.....
00	.....	.....	137.00	.....
000	.....	.....	166.00	.....
0000	.....	.....	195.00	.....

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap Key Each	½ In. or Pendant Cap Keyless Each	½ In. or Pendant Cap Pull Each	¾ In. Cap Key Each	¾ In. Cap Keyless Each	¾ In. Cap Pull Each
$0.33	$0.30	$0.55	$0.39	$0.36	$0.61

Less 1-5th standard package	25%
1-5th to standard package	32%
Standard package	37%

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb.
Rubber tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb.
Wire solder, less 100 lb. 27c. lb., 100 lb. lots	29c. lb.
Soldering paste, 2 oz. cans	$1.00 doz.

ENCLOSED SWITCHES, KNIFE—Safety type, externally operated, 250 d.c. or a.c., N.E.C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$4.50	$6.00	$7.25
60	7.50	8.25	10.50
100	10.50	13.00	22.50
200	16.00	20.00	36.00

Discounts:	
Less than $25.00 list value	30%
$25 to $50 list value	30–5%
$50 list value or over	35%